ESSENTIAL QUESTION

How do we use and control thermal energy in a system?

Introduction to Culminating Project and Individual Project Organizer

Lift-Off Task: Build a Working System

Formative Assessment—Individual Project Organizer Lift-Off Task

Task 1: Compare Thermal Energy and Temperature

Formative Assessment—Individual Project Organizer Task 1

Task 2: Thermal Energy Transfer

Formative Assessment—Individual Project Organizer Task 2

Task 3: Insulators and Conductors

Formative Assessment—Individual Project Organizer Task 3

Task 4: Mass and Thermal Energy

Formative Assessment—Individual Project Organizer Task 4

Culminating Project: The Device to Minimize or Maximize Thermal Energy Transfer

Group and Individual Assessment

Connect the Sixth-Grade Energy Unit with Prior Knowledge

This summary is based on information found in the NGSS Framework.

Core Idea PS3 Energy

At the macroscopic level, energy can be seen or felt or heard as motion, light, sound, electrical fields, magnetic fields, and thermal energy. At the microscopic level, energy can be modeled either as particle motion or as particles stored in force fields (electric, magnetic, or gravitational).

The goal of this sixth-grade Energy Unit is to help students make connections between the concepts of energy, particle motion, temperature, and the transfer of the energy in motion from one place to another. In this unit, moving particles or motion energy will be identified as kinetic energy. Temperature will be identified as the average kinetic energy of particles of matter. Through investigations, students will determine that there is a relationship between the temperature of a system and the total energy in the system, depending on the amount of matter present. By the end of this unit, students will connect the concepts that all matter (above absolute zero) contains thermal energy, or random motion of particles, and that thermal energy transfer is the transfer of energy from an area of higher temperature (more particle movement) to an area of lower temperature (less particle movement).

In the Energy Unit, students plan an investigation about thermal energy transfer, construct an argument about thermal energy transfer, and design and construct a device to minimize or maximize thermal energy transfer. As you move into sixth-grade curriculum, it is important to know that students have not yet defined the word *energy* and have only used the word to identify a larger concept. Defining energy is a learning objective for middle school students.

The following are the sixth-grade energy performance expectations.

MS-PS3-3 **Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*** [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [*Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.*]

MS-PS3-4 **Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.** [Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] [*Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.*]

MS-PS3–5 **Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.** [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [*Assessment Boundary: Assessment does not include calculations of energy.*]

*This performance expectation integrates traditional science content with engineering through a Practice or Disciplinary Core Idea.

Although students have not specifically defined the word *energy*, the concept of energy is first introduced in kindergarten. In kindergarten, students learn that the sun warms the Earth. They also start learning about the engineering design process as applied to energy. Students design and build a structure that will reduce the warming effect of sunlight on an area. At the kindergarten level, students are not required to practice quantitative measuring; they focus on the qualitative concept of warmer and cooler. In sixth grade, students will build on this knowledge and again use the engineering design process, but this time they will construct a device that either minimizes or maximizes thermal energy transfer.

The following are the kindergarten performance expectations.

K-PS3-1 **Make observations to determine the effect of sunlight on Earth's surface.** [Clarification Statement: Examples of Earth's surface could include sand, soil, rocks, and water.] [*Assessment Boundary: Assessment of temperature is limited to relative measures such as warmer/cooler.*]

K-PS3-2 **Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.*** [Clarification Statement: Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.]

*This performance expectation integrates traditional science content with engineering through a Practice or Disciplinary Core Idea.

Students revisit the concept of energy in fourth grade. In this grade, students start to learn about characteristics of energy. Students learn that energy is present whenever there are moving objects, sound, light, or heat. Students explain that the speed of an object relates to the energy of that object. In essence, the faster a given object is moving, the more energy it possesses. In sixth grade, students will give this energy of motion a name: kinetic energy.

In fourth grade, students provide evidence that energy can be transferred from place to place by moving objects or by sound, light, heat, and electrical currents. Again, the observations are conceptual and qualitative, without requiring quantitative measurements. In comparison, in sixth grade students specifically investigate thermal energy transfer using temperature measurements. It is in sixth grade that students conduct experiments to demonstrate the concept that energy moves out of higher temperature objects and into lower temperature ones.

The engineering theme is explicit in energy curriculum starting in kindergarten. In kindergarten, students build a structure to reduce the warming effect of the sun. Students design, build, and test a device that will convert energy from one form to another in fourth grade. In sixth grade, students build a device to minimize or maximize thermal energy.

Note that there are some energy concepts—specifically light, the relationship between energy forces, and energy in chemical processes—that students learn in fourth grade, but that are not addressed in the sixth-grade curriculum. These topics are addressed in grades 7–12.

The following are the fourth-grade energy performance expectations.

4-PS3-1 **Use evidence to construct an explanation relating the speed of an object to the energy of that object.** [*Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.*]

4-PS3-2 **Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.** [*Assessment Boundary: Assessment does not include quantitative measurements of energy.*]

4-PS3-3 **Ask questions and predict outcomes about the changes in energy that occur when objects collide.** [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [*Assessment Boundary: Assessment does not include quantitative measurements of energy.*]

4-PS3-4 **Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*** [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [*Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.*]

4-ESS3-1 **Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.** [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]

*This performance expectation integrates traditional science content with engineering through a Practice or Disciplinary Core Idea.

Connect Core Ideas, Scientific Practices, and Crosscutting Concepts from K–6

	Kindergarten	Fourth Grade	Sixth Grade
Disciplinary Core Idea PS3.A **Definitions of Energy**		• The faster a given object is moving, the more energy it possesses. (4-PS3-1) • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2; 4-PS3-3)	• Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1) • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3; MS-PS3-4)
Disciplinary Core Idea PS3.B **Conservation of Energy and Energy Transfer**	• Sunlight warms Earth's surface. (K-PS3-1), (K-PS3-2)	• Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2; 4-PS3-3) • Light also transfers energy from place to place. (4-PS3-2) • Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2; 4-PS3-4)	• When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5) • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4) • Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)
Disciplinary Core Idea PS3.C **Relationship Between Energy and Forces**		• When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3)	
Disciplinary Core Idea PS3.D **Energy in Chemical Processes and Everyday Life**		• The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)	

	Kindergarten	Fourth Grade	Sixth Grade
ETS1.A **Defining and Delimiting an Engineering Problem**		• Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (secondary to 4-PS3-4)	• The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary to MS-PS3-3)
ETS1.B **Developing Possible Solutions**			• A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)
Science and Engineering Practices	• Constructing Explanations and Designing Solutions • Planning and Carrying Out Investigations	• Constructing Explanations and Designing Solutions • Asking Questions and Defining Problems • Planning and Carrying Out Investigations • Obtaining, Evaluating, and Communicating Information	• Constructing Explanations and Designing Solutions • Planning and Carrying Out Investigations • Developing and Using Models • Analyzing and Interpreting Data • Engaging in Argument from Evidence
Crosscutting Concepts	• Cause and Effect	• Cause and Effect • Energy and Matter	• Energy and Matter • Scale, Proportion, and Quantity • Systems and System Models

Standards and Objectives

Energy Standards

NGSS Performance Expectations

MS-PS3-3 **Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*** [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [*Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.*]

MS-PS3-4 **Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.** [Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] [*Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.*]

MS-PS3–5 **Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.** [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [*Assessment Boundary: Assessment does not include calculations of energy.*]

MS-ETS1-1 **Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**

MS-ETS1-4 **Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**

*This performance expectation integrates traditional science content with engineering through a Practice or Disciplinary Core Idea.

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3; MS-PS3-4)

PS3.B: Conservation of Energy and Energy Transfer

- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4)
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)

ETS1.A: Defining and Delimiting an Engineering Problem

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary to MS-PS3-3)

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)

Science and Engineering Practices

Planning and Carrying Out Investigations

- Plan an investigation individually and collaboratively, and in the design; identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS3-4)

Constructing Explanations and Designing Solutions

- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-PS3-3)

Engaging in Argument from Evidence

- Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3–5)

Crosscutting Concepts

Energy and Matter

- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)
- Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion). (MS-PS3-5)

Systems and System Models

- Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems. (MS-PS3-2)

Connections to Nature of Science

Scientific Knowledge Is Based on Empirical Evidence

- Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS3-4; MS-PS3-5)

Standards by Task

Tasks	Descriptions of Tasks	Performance Expectations*	Disciplinary Core Ideas and Crosscutting Concepts	Science and Engineering Practices
Lift-Off Task: Build a Working System	• Students build a flashlight with materials given to them. • Students create a model for the mechanisms in the flashlight system. • Students revise their model if parameters of the flashlight change.		**ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3) **Crosscutting Concepts** • Energy and Matter • Systems and System Models	• Developing and Using Models
Task 1: Compare Thermal Energy and Temperature	• Students become a particle to represent kinetic motion. • Students review energy vocabulary. • Students view three ice cube demonstrations to learn how the number of particles at different temperatures relates to amount of thermal energy. • Students use the context of hot chocolate to investigate how more particles at the same temperature equals more thermal energy.		**PS3.A: Definitions of Energy** • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3; MS-PS3-4) **Crosscutting Concepts** • Energy and Matter • Systems and System Models	• Developing and Using Models • Engaging in Argument from Evidence • Analyzing and Interpreting Data
Task 2: Thermal Energy Transfer	• Students rotate through six lab stations that exemplify the concept of thermal energy transfer. • Students apply their knowledge of thermal energy transfer to answer a real-world question.	• Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (MS-PS3-5)	**PS3.B: Conservation of Energy and Energy Transfer** • Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3) **Crosscutting Concepts** • Energy and Matter • Systems and System Models	• Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence

*The three dimensions of the Performance Expectations are formatively assessed in the unit tasks. The Culminating Project only assesses parts of each Performance Expectation.

Tasks	Descriptions of Tasks	Performance Expectations*	Disciplinary Core Ideas and Crosscutting Concepts	Science and Engineering Practices
Task 3: Insulators and Conductors	• Students conduct an investigation to determine which materials are the best thermal conductors and insulators. • Students design and conduct their own experiment to test a conducting or insulating material using an ice pop.	• Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (MS-PS3-3) • Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (MS-PS3-5)	**PS3.B: Conservation of Energy and Energy Transfer** • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4) • Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3) **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3) **Crosscutting Concepts** • Energy and Matter • Systems and System Models	• Planning and Carrying Out Investigations • Constructing Explanations and Designing Solutions
Task 4: Mass and Thermal Energy	• Students design and conduct an experiment to determine how the mass of oatmeal affects thermal energy transfer.	• Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. (MS-PS3-4)	**PS3.B: Conservation of Energy and Energy Transfer** • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4) • Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3) **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3) **Crosscutting Concepts** • Energy and Matter • Systems and System Models	• Asking Questions and Defining Problems • Planning and Carrying Out Investigations • Analyzing and Interpreting Data • Constructing Explanations and Designing Solutions

Tasks	Descriptions of Tasks	Performance Expectations*	Disciplinary Core Ideas and Crosscutting Concepts	Science and Engineering Practices
Culminating Projects: **The Device to Minimize or Maximize Thermal Energy Transfer**	• Students design and test a device that either maximizes or minimizes thermal energy transfer. • Students revise their design based on data from testing. • Students write up a Patent Application for the device.	• Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (MS-PS3-3) • Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. (MS-PS3-4) • Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (MS-PS3-5)	**PS3.A: Definitions of Energy** • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3; MS-PS3-4) **PS3.B: Conservation of Energy and Energy Transfer** • When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5) • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4) • Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3) **ETS1.A: Defining and Delimiting an Engineering Problem** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary to MS-PS3-3) **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	• Asking Questions and Defining Problems • Planning and Carrying Out Investigations • Analyzing and Interpreting Data • Constructing Explanations and Designing Solutions

*The three dimensions of the Performance Expectations are formatively assessed in the unit tasks. The Culminating Project only assesses parts of each Performance Expectation.

Misconceptions

Knowing what is wrong is as important as knowing what is right.

Lift-Off Task: Build a Working System

Misconceptions	Accurate Concept
There are different forms of energy, such as thermal energy, mechanical energy, and chemical energy.	The nature of the energy in each of these is not distinct—they all are ultimately, at the atomic scale, some mixture of kinetic energy, stored energy, and radiation. In addition, it is misleading to call sound or light a form of energy; they are phenomena that, among their other properties, transfer energy from place to place and between objects.

Task 1: Compare Thermal Energy and Temperature

Misconceptions	Accurate Concept
Heat is a substance.	Heat is energy.
Temperature depends on the size of an object.	Temperature does not depend on size. For example, a swimmer has a higher temperature than the ocean the swimmer swims in.
Heat and temperature are the same.	Heat is transferred from one object to another and may result in change of temperature of the objects. ● Heat is passed from one place to another. ● Heat is energy measured in joules (J). ● Heat can be gained or lost. ● Temperature is how hot or cold a substance is. ● Temperature is the average kinetic energy in a substance. ● Temperature is measured in degrees using one of these scales: Kelvin (K), Celsius (C), or Fahrenheit (F).
Heat and cold are substances.	● Heat is energy that can be gained or lost; cold is the absence of heat. ● Heat is the energy that can be gained or lost; cold refers to the temperature.
Heat and thermal energy are the same.	● Heat is energy in transit due to differences in temperature between two systems; thermal energy is not in transit, but remains as part of the internal energy of the system. ● Heat can not be stored or contained by a system because it is a process function; thermal energy is part of the internal energy in a system.
Heat versus temperature versus thermal energy: short video clip	https://youtu.be/yXT012us9ng
For more information	physicsclassroom.com

Task 2: Thermal Energy Transfer

Misconceptions	Accurate Concept
Cold is transferred from one object to another.	Heat is transferred from one object to another.
Heat moves from cooler objects to warmer objects.	Heat moves from an area or object with higher thermal energy to an area or object with lower thermal energy.
Heat and cold are different.	Cold is the absence of heat. Cold is a temperature.
Objects (blankets, gloves) produce their own heat.	Objects (blankets, gloves) keep things warm by trapping heat.

Task 3: Insulators and Conductors

Misconceptions	Accurate Concept
Conductors become warm but do not readily become cold.	Conductors gain and lose heat easily.
Some substances do not heat up.	All substances can heat up, although some gain heat more easily or faster than others.
Insulators have heat (e.g., a sweater keeps you warm because it is warm).	A sweater can be an insulator if it reduces the transfer of thermal energy from your body to the outside air.

Task 4: Mass and Thermal Energy

Misconceptions	Accurate Concept
The change in temperature over time is constant for each material and does not depend on size or mass.	The change in temperature depends on the nature of the matter and its size.
The time it takes to cook a cake doesn't depend on the size of the cake.	Assuming both cakes have the same ingredients and are in the same oven, a large cake needs more time to cook because it has more substance, and thus a greater number of particles. The more particles, the more thermal energy is needed to be transferred to these particles. So, the large cake needs more time in the oven to cook.

Resources

Experimental Design

https://nces.ed.gov/nceskids/createagraph/

Question: What is a variable?

Answer: A variable is an object, event, idea, feeling, time period, or anything else that can be measured during an experiment. There are two types of variables—independent and dependent.

Question: What is an independent variable?

Answer: An independent variable is a variable that scientists change in the experiment. The variable is not changed by other variables in the experiment. The independent variable is also kept the same when repeating the same experiment over and over. For example, if you wanted to see if different hair colors grow at different rates, you would measure blonde hair, brown hair, black hair, and red hair at time 0 and at 30 days. The independent variable is the hair color. The dependent variable is the measurement, or growth. The standard factors are hair, measuring the hair length at time 0 and time 30 days, age of subject, what the subject ate during that 30 days, the amount of sleep the subject got over the 30 days, etc. The only variable that should change is the hair color.

Question: What is a dependent variable?

Answer: A dependent variable is something that depends on the other variable. A dependent variable is what is actually measured in the experiment. In the previous example, the amount the hair grew over 30 days is the dependent variable. Scientists measured the growth of the hair, and the growth of the different hairs was only due to the color change, or the independent variable. If you measured how far a snail travels over different surfaces in 60 minutes, the different surfaces would be the independent variable, and the distance traveled would be the dependent variable.

The rule when talking about the relationship is that the (**independent variable**) causes a change in the (**dependent variable**), or that the (**dependent variable**) variation is dependent on the different (**independent variables**).

For example: (Time spent studying) causes a change in (test score); it is not possible that (test score) could cause a change in (time spent studying).

Recommended Videos

BrainPop: Scientific Method**.** https://www.brainpop.com/science/scientificinquiry/scientificmethod/

The Human Spark**.** http://www.pbs.org/wnet/humanspark/lessons/experimenting-with-experiments/lesson-activities/?p=431

Recommended Reading

Science Buddies: Variables in Your Science Fair Project.

http://www.sciencebuddies.org/science-fair-projects/project_variables.shtml#whatarevariables

mathxscience.com: Experimental Variables**.** http://mathxscience.com/scientific_method_variables.html

Science Made Simple: Designing Science Fair Experiments**.** http://www.sciencemadesimple.com/science_fair_experiment.html

"Wisconsin Online Heat Transfer." WGBH Educational Foundation.
http://www.pbslearningmedia.org/asset/lsps07_int_heattransfer/

StudyJams! Heat. Video. Scholastic, Inc. http://studyjams.scholastic.com/studyjams/jams/science/energy-light-sound/heat.htm

The Human Spark. http://www.pbs.org/wnet/humanspark/lessons/experimenting-with-experiments/lesson-activities/?p=431

Culminating Projects

Essential Question: How do we use and control thermal energy in a system?

Introduction

The world we live in is full of energy. Energy is one of the most fundamental parts of our universe. Plants and animals need energy to grow and reproduce. Cars need energy to move. Refrigerators need energy to keep things cool. We need energy to cook our food. Everything around us and everything we do is connected to energy in one form or another. In this Energy Unit, students will be specifically focusing on thermal energy and thermal energy transfer. Through investigation, activities, and discussion students will make connections between the concepts of energy, particle motion, temperature, and the transfer of the energy in motion from one place to another. In the end, students will design, construct, test, and modify a device that minimizes or maximizes thermal energy. They will have a choice of designing a device to bake cookies with the power of the sun, gloves to keep hands warm in freezing cold rivers, a device to keep ice structures frozen, or a hot tub that stays warm. In the end, students will complete an Individual Culminating Project in which they will individually write a Patent Application for their device.

The student's device will allow them to apply the following energy concepts to their engineered device:

- Energy is transferred out of hotter regions or objects into cooler regions or objects.
- There is a difference between an insulator and a conductor.
- The mass or size of an object or substance relates to thermal energy and thermal energy transfer.
- It is important to test and modify engineered devices to improve the quality of the device.

Objectives

- Design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
- Develop and revise the design of a device.
- Conduct investigations to test how thermal energy transfers in a device.
- Plan an investigation to determine the relationship between energy transfer, type of matter, mass, and change in kinetic energy.
- Construct an argument to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Group Culminating Project: The Device to Minimize or Maximize Thermal Energy Transfer

1. Introduce the Culminating Project after the Lift-Off Task.
2. Read over with students the student instructions and the criteria for the Culminating Project.
3. Give students time to discuss their initial ideas about the Culminating Project in their small groups.
4. Ask students if they have any clarifying questions about the Culminating Project.
5. Have students turn to the Individual Project Organizer for the Lift-Off Task.
6. Describe the structure and function of the Individual Project Organizer to students. The Individual Project Organizer:
    - Should be completed individually
    - Will help students reflect on what they learned in each task
    - Applies the content and practices in each task to the Culminating Project
    - Helps students gradually plan and carry out the Culminating Project throughout the unit so that all the work does not have to be done at the end of the unit
7. Make sure students fill out the Individual Project Organizer after each task in order to start them thinking about the project from the very beginning of the unit. The table below summarizes how the Individual Project Organizer connects to the Culminating Project.

NOTE

It is important that students start to bring in materials and building before the end of the Energy Unit. The "Progress of the Culminating Project" column in the chart below gives an approximate time line for what students might do for the Culminating Project after each task.

<table>
<tr><th>Task</th><th>Individual Project Organizer</th><th>Connect the Individual Project Organizer to the Group Culminating Project</th><th>Progress of Group Culminating Project</th></tr>
<tr><td>Lift-Off Task
Build a Working System</td><td>• Identify the client, the challenges, the “need-to-knows” of the device.
• Begin to brainstorm possible designs for the device.</td><td>Explore the concept of a system and the practice of developing and using models.</td><td>Students should
• Pick a client.
• Brainstorm what their device will look like and will do.</td></tr>
<tr><td>Task 1
Compare Thermal Energy and Temperature</td><td>Identify the difference between thermal energy and temperature in objects/substances at the particle level.</td><td>Identify in the device where the temperature is least and greatest.</td><td>Students should
• Refine their design.
• Brainstorm how they will maintain the temperatures they need or increase the temperature to the desired temperature.
Ask students to start bringing in materials to build their device.</td></tr>
<tr><td>Task 2
Thermal Energy Transfer</td><td>Sketch a model of the device, including dimensions and materials, and identify regions involved in thermal energy transfer.</td><td>Sketch a model of the device including dimensions, materials, and identifying regions involved in thermal energy transfer. Identify whether the device minimizes or maximizes thermal energy transfer.</td><td>Students should
• Create a design for their device to minimize or maximize thermal energy transfer.
Ask students to bring in materials they might need to build their device.</td></tr>
<tr><td>Task 3
Insulators and Conductors</td><td>• Make a list of possible conducting/insulating materials for their device.
• Explain, using data and appropriate vocabulary, why those materials would work in their device.
• Redraw the model of their device.</td><td>Make a list of possible conducting/insulating materials for their device and explain, using data and appropriate vocabulary, why those materials would work in their device.</td><td>Students should
• Revise their design based on what they have learned.
• Select their materials for their device.
Ask students to
• Bring in any additional materials they may need for their device.
• Start building their device.</td></tr>
<tr><td>Task 4
Mass and Thermal Energy</td><td>Decide on the size/mass of the cookie, hand, ice structure, or volume of water to be used in the device, and
• Write an argument for their choice using evidence from the task.
• Sketch a model of the device.</td><td>Decide on the size/mass of the cookie, hand, ice structure, or volume of water to be used in the device, and make an argument for their choice using evidence from the task.
Make a final sketch of the model of their device including parts, materials, and dimensions of the device.</td><td>Students should
• Make a final sketch of their model of the device. This will go into their Patent Application.
Ask students to continue building their device, then test it, then revise it, and finally sketch a revised model of the device.</td></tr>
</table>

NOTE

We strongly encourage you to review and provide feedback when students complete each task of the Individual Project Organizer. We urge you to ask students to revise their work and incorporate your feedback in the Individual Project Organizer so that they can improve the quality of their Individual Culminating Project (the Patent Application).

8. After all the learning tasks are completed and all the parts of the Individual Project Organizer are completed, students can make any additional revisions to their device design plans that they deem necessary for the device to work. Students should continue building their devices. The Individual Project Organizers should be used as reference for students to help them build their device and understand why they are building the device as they planned throughout the unit.
9. Encourage, support, and assess student understanding of energy concepts while students are building their device.
    - Move from group to group and ask questions to help students move from simply building a device to understanding their device to being able to communicate their understanding of the device.
    - Sample questions might be:
        - Why did you choose material "X" over material "Y"?
        - Why did you make your device this size?
        - Show me where thermal energy transfer is occurring.
        - Explain to me where thermal energy transfer is occurring.
        - Are you maximizing or minimizing thermal energy transfer?
        - How are you maximizing or minimizing thermal energy transfer?
        - Why does the mass of the (cookie, hand, ice, volume of water) matter?
        - What might happen if you used (more cookie dough, a bigger hand, a larger ice sculpture, more water)?
10. Test the device.
    - After students finish building their device, they will test their device. They should do more than one trial run. Explain to students that they will gather and record data for each trial they conduct. They will data record their data in their science notebook and use the data to revise their device or recommend revisions to the device, depending on the class time line. They will also incorporate their data in the Patent Application.
11. Revise the device.
    - Allow time for students to revise their design models (plans). This revision may be done on paper by redrawing their model, including descriptions of what and why they made the revisions. If there is class time available, students could actually modify their device and conduct new trial runs with their new device.
12. Present the device.
    - Each group will prepare a short presentation of their device.
    - Review the requirements of the presentation as found in the Student Edition. The presentation should include demonstration of the device, description of thermal energy transfer in the device, and analysis of the data from their investigation.
    - Pick one row from the Oral Presentation Rubric for students to address during the presentation. Review the Oral Presentation Rubric requirement(s) for the presentation.

Individual Culminating Project

Instructions for the Individual Culminating Project: The Patent Application

1. Review the requirements of the Patent Application.
2. Review the Science Content Rubric and the Science and Engineering Practices Rubric as they apply to the Energy Unit.
3. Give students time to write out their own Patent Application. This is an individual task, not a group project.
4. Have students turn to the Peer Feedback for Patent Application form. Ask students to switch Patent Applications with another student. Give students time to read and make comments on the Peer Feedback form.
5. Have students revise their Patent Application using the feedback from the Peer Feedback form.

Culminating Project Assessment

Overview

The Group Culminating Project will be assessed using:

- The **Oral Presentation Rubric**
    - Select one area from this rubric for your students to focus on during their presentations.

The Individual Culminating Project will be assessed using:

- The **Science and Engineering Practices Rubric**
    - “Asking Questions and Defining Problems” row (second half)
    - “Developing and Using Models” row (first half)
    - “Planning the Investigation or Design” row (second half)
    - “Conducting Investigation or Testing Design” row
    - “Constructing Explanations and Designing Solutions” row (second half)
- The **Science Content Rubric**

Science and Engineering Practices Rubric

The Energy Unit will be assessed using the highlighted rows.

SCIENCE AND ENGINEERING PRACTICES RUBRIC				
SCORING DOMAIN	**EMERGING**	**DEVELOPING**	**PROFICIENT**	**ADVANCED**
ASKING QUESTIONS AND DEFINING PROBLEMS ❑ No Evidence*	Asks general questions that cannot be investigated	Asks specific questions that can be investigated but do not require empirical evidence	Asks questions that require empirical evidence to answer	Asks questions that require empirical evidence to answer and evaluates the testability of the questions
	Writes a problem or design statement but it does not match the intent of the problem or the need of the client	Writes a problem or design statement that matches the intent of the problem or the need of the client with minor errors	Writes a problem or design statement that accurately matches the intent of the problem or the needs of the client	Writes a problem or design statement that accurately and completely matches the intent of the problem or the need of the client
DEVELOPING AND USING MODELS ❑ No Evidence*	Makes models (drawings, diagrams, or other) with major errors	Makes models (drawings, diagrams, or other) to represent the process or system to be investigated with minor errors	Makes accurate and labeled models (drawings, diagrams, or other) to represent the process or system to be investigated	Makes accurate and labeled models (drawings, diagrams, or other) to represent the process or system to be investigated and explains the model
	Explains the limitations of the model with major errors	Explains the limitations of the model with minor errors	Explains the limitations of the model as a representation of the system or process	Explains the limitations of the model as a representation of the system or process
PLANNING THE INVESTIGATION OR DESIGN ❑ No Evidence*	Plans an investigation that will not produce relevant data to answer the empirical question(s)	Plans an investigation that will produce some relevant data to answer the empirical question(s)	Plans an investigation that will produce relevant data to answer the empirical question(s) and identifies the dependent and independent variables when applicable	Plans an investigation that will completely produce relevant and adequate amounts of data to answer the empirical question(s) and identifies the dependent and independent variables when applicable
	Plans a design that does not match the criteria, constraints, and intent of the problem	Plans a design and writes an explanation that partially matches the criteria, constraints, and intent of the problem	Plans a design and writes an explanation that accurately and adequately matches the criteria, constraints, and intent of the problem	Plans a design and writes a detailed explanation that accurately and completely matches the criteria, constraints, and intent of the problem
CONDUCTING INVESTIGATION OR TESTING DESIGN ❑ No Evidence*	Writes procedures that lack detail so the procedures cannot be duplicated by another person	Writes procedures with enough detail that another person can duplicate (replicable) but does not conduct a sufficient number of trials	Writes detailed replicable procedures with descriptions of the measurements, tools, or instruments and conducts adequate number of trials	Writes detailed replicable procedures with descriptions of the measurements, tools, or instruments and conducts adequate number of trials with an explanation for the proposed data collection

* If there is no student response then check the No Evidence box.

The Energy Unit will be assessed using the highlighted rows.

SCIENCE AND ENGINEERING PRACTICES RUBRIC				
SCORING DOMAIN	**EMERGING**	**DEVELOPING**	**PROFICIENT**	**ADVANCED**
ANALYZING AND INTERPRETING DATA *Accurately labeled" means inclusion of title, column titles, description of units, proper intervals.* ❏ No Evidence*	Makes spreadsheets, data tables, charts, or graphs that are not accurately labeled or do not display all the data	Makes accurate and labeled spreadsheets, data tables, charts, or graphs to summarize and display data but does not arrange the data to examine the relationships between variables	Makes accurate and labeled spreadsheets, data tables, charts, and/or graphs to summarize and display data and arranges the data to examine relationships between variables	Makes accurate and labeled spreadsheets, data tables, charts, and/or graphs and uses more than one of these methods to summarize and display data; arranges the data to examine relationships between variables
	Uses inappropriate methods or makes major errors analyzing the data	Uses appropriate methods but makes minor errors analyzing the data	Uses appropriate methods to accurately and carefully identify patterns **or** explains possible error or limitations of analyzing the data	Uses appropriate methods to accurately and carefully identify patterns **and** explains possible error or limitations of analyzing the data
CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS ❏ No Evidence*	Constructs an explanation that includes an inappropriate claim, inaccurate evidence, and/or unclear reasoning	Constructs or evaluates an explanation consisting of minimal claim(s), limited sources of accurate evidence, and/or minimal reasoning	Constructs or evaluates an explanation that includes a claim, multiple sources of accurate evidence, and reasoning using accurate and adequate scientific ideas or principles	Constructs, evaluates, or revises an explanation that includes a claim, multiple sources of accurate evidence, and reasoning using accurate and adequate scientific ideas or principles
	Uses no data to evaluate how well the design answers the problem and the redesign of the original model or prototype is inappropriate or incomplete	Uses minimal data to evaluate how well the design answers the problem and describes an appropriate redesign of the original model or prototype with minor errors	Uses adequate data to evaluate how well the design answers the problem and accurately explains an appropriate redesign of the original model or prototype	Uses adequate data to evaluate how well the design answers the problem and accurately provides a detailed rationale for the appropriate redesign of the original model or prototype
ENGAGING IN ARGUMENTS FROM EVIDENCE ❏ No Evidence*	Constructs an argument that includes an inappropriate claim, inaccurate evidence, and/or unclear reasoning	Constructs or evaluates an argument consisting of minimal claim(s), limited sources of evidence, **or** minimal reasoning	Constructs and/or evaluates an argument consisting of appropriate claim(s), multiple sources of evidence, and reasoning using accurate and adequate scientific ideas or principles	Constructs, evaluates, or revises an argument consisting of appropriate claim(s), multiple sources of evidence, and reasoning using accurate and adequate scientific ideas or principles
COMMUNICATING INFORMATION ❏ No Evidence*	Communicates information that is inaccurate and/or inconsistent with the evidence	Communicates accurate and minimal information consistent with the evidence but does not explain the implications **or** limitations of the investigation or design	Communicates accurate, clear, and adequate information consistent with the evidence and explains the implications and/or limitations of the investigation or design	Communicates accurate, clear, and complete information consistent with the evidence and provides a rationale for the implications and limitations of the investigation or design

* If there is no student response then check the No Evidence box.

Science Content Rubric

SCIENCE CONTENT RUBRIC				
THE STUDENT DEMONSTRATES THEIR SCIENTIFIC KNOWLEDGE OF THE FOLLOWING CONTENT STANDARD	EMERGING	DEVELOPING	PROFICIENT	ADVANCED
A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (ETS1.B)	Constructs an explanation about how the device was modified based on no investigation data and/or with major errors	Constructs an explanation about how the device was modified based on limited investigation data and/or with minor errors	Constructs an accurate explanation about how the device was modified based on investigation data	Constructs an accurate and detailed explanation about how the device was modified based on investigation data
Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3.B)	Constructs an explanation about energy transfer with no evidence and/or major errors	Constructs an explanation about energy transfer with limited evidence and/or minor errors	Constructs an accurate explanation about energy transfer with evidence	Constructs a detailed accurate explanation about energy transfer with evidence

Oral Presentation Rubric

ORAL PRESENTATION RUBRIC							
SCORING DOMAIN	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
CLARITY *What is the evidence that the student can present a clear perspective and line of reasoning?*	Presents an unclear perspective Line of reasoning is absent, unclear, or difficult to follow	❑	Presents a general perspective Line of reasoning can be followed	❑	Presents a clear perspective Line of reasoning is clear and easy to follow Addresses alternative or opposing perspectives when appropriate	❑	Presents a clear and original perspective Line of reasoning is clear and convincing Addresses alternative or opposing perspectives in a way that sharpens one's own perspective
EVIDENCE *What is the evidence that the student can present a perspective with supportive evidence*?	Draws on facts, experience, or research in a minimal way Demonstrates limited understanding of the topic	❑	Draws on facts, experience, and/or research inconsistently Demonstrates an incomplete or uneven understanding of the topic	❑	Draws on facts, experiences, and research to support a perspective Demonstrates an understanding of the topic	❑	Synthesizes facts, experience, and research to support a perspective Demonstrate an in-depth understanding of the topic
ORGANIZATION *What is the evidence that the student can use language appropriately and fluidly to support audience understanding?*	Lack of organization makes it difficult to follow the presenter's ideas and line of reasoning	❑	Inconsistencies in organization and limited use of transitions detract from audience understanding of line of reasoning	❑	Organization is appropriate to the purpose, audience, and task and reveals the line of reasoning; transitions guide audience understanding	❑	Organization is appropriate to the purpose and audience and supports the line of reasoning; effectively hooks and sustains audience engagement, while providing a convincing conclusion
LANGUAGE USE *What is the evidence that the student can use language appropriately and fluidly to support audience understanding?*	Uses language and style that are unsuited to the purpose, audience, and task Stumbles over words, interfering with audience understanding	❑	Uses language and style that are at times unsuited to the purpose, audience, and task Speaking is fluid with minor lapses of awkward or incorrect language use that detracts from audience understanding	❑	Uses appropriate language and style that are suited to the purpose, audience, and task Speaking is fluid and easy to follow	❑	Uses sophisticated and varied language that is suited to the purpose, audience, and task Speaking is consistently fluid and easy to follow

ORAL PRESENTATION RUBRIC							
SCORING DOMAIN	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
USE OF DIGITAL MEDIA / VISUAL DISPLAYS *What is the evidence that the student can use digital media/visual displays to engage and support audience understanding?*	Digital media or visual displays are confusing, extraneous, or distracting	❑	Digital media or visual displays are informative and relevant	❑	Digital media or visual displays are appealing, informative, and support audience engagement and understanding	❑	Digital media or visual displays are polished, informative, and support audience engagement and understanding
PRESENTATION SKILLS *What is the evidence that the student can control and use appropriate body language and speaking skills to support audience engagement?*	Makes minimal use of presentation skills: lacks control of body posture; does not make eye contact; voice is unclear and/or inaudible; and pace of presentation is too slow or too rushed Presenter's energy and affect are unsuitable for the audience and purpose of the presentation	❑	Demonstrates a command of some aspects of presentation skills, including control of body posture and gestures, language fluency, eye contact, clear and audible voice, and appropriate pacing Presenter's energy and/or affect are usually appropriate for the audience and purpose of the presentation, with minor lapses	❑	Demonstrates a command of presentation skills, including control of body posture and gestures, eye contact, clear and audible voice, and appropriate pacing Presenter's energy and affect are appropriate for the audience and support engagement	❑	Demonstrates consistent command of presentation skills, including control of body posture and gestures, eye contact, clear and audible voice, and appropriate pacing, in a way that keeps the audience engaged Presenter maintains a presence and a captivating energy that is appropriate to the audience and purpose of the presentation
INTERACTION WITH AUDIENCE *What is the evidence that the student can respond to audience questions effectively?*	Provides a vague response to questions; demonstrates a minimal command of the facts or understanding of the topic	❑	Provides an indirect or partial response to questions; demonstrates a partial command of the facts or understanding of the topic	❑	Provides an indirect or partial response to questions; demonstrates a partial command of the facts or understanding of the topic	❑	Provides a precise and persuasive response to questions; demonstrates an in-depth understanding of the facts and topic

Materials

Lift-Off Task: Build a Working System

Student Materials (for each group)

- 2 size D batteries
- 2 lengths of #22 insulated wire (5" each) with the insulation stripped off both ends
- Toilet tissue roll cut into a 4" length, or
- 4" x 8" piece of heavy paper or card stock rolled and taped to create a 4″tall cylinder the same diameter as the batteries
- 3 volt flashlight bulb
- 2 brass paper fasteners
- 1" x 3" strip of cardboard
- Paper clip
- Small paper cup
- Clear tape

Teacher Materials

- "Collections, Systems, and Models" digital slide presentation
- Student Participation Observations form
- Stamp (to record student participation)

Task 1: Compare Thermal Energy and Temperature

Teacher Materials

- "Energy Terms" digital slide presentation
- 250 mL beaker (for measuring hot and room temperature water)
- 50 mL beaker (for measuring hot and room temperature water)
- Measuring cup or beaker for ice (about $\frac{1}{2}$ c or 100 mL)
- 400 mL beakers (2, for ice and water combination)
- 2 plates to put the remaining ice on after 1 minute
- Room temperature water
- Hot water
- Ice
- Timer
- Strainer (to strain ice out of water)
- Hot plate and a pot or an electric tea kettle
- Vocabulary cards for the wall concept map (write each of the following words on an index card: heat, thermal energy, temperature, kinetic energy, particles)
- Tape or magnets to hold vocabulary cards on wall or board

Task 2: Thermal Energy Transfer

Student Materials (for each lab station)

Prepare copies of the Lab Station descriptions for each Lab Station.

Lab Station 1: Blue and Red Water (Convection in Water)

- 2 same-size bottles or flasks
- Warm water source with red coloring added
- Cold water source with blue coloring added
- Index card, playing card, or piece of flat plastic
- Large shallow tub or pan to catch spills
- Paper towels

Lab Station 2: Cold Water and a Balloon (Convection in Gas)

- Empty glass bottle, plastic bottle, or flask
- Balloons (1 per group)
- Container with ice
- Container with hot water
- Timer

Lab Station 3: Conductometer (Conduction in Metal)

- Flame source (e.g., candle or Bunsen burner)
- Conductometer
- Wax
- Container with ice (for Extension Challenge)
- Paper towels

Lab Station 4: Butter Boat (Conduction in Metal)

- Container of very hot water
- Butter, about 1 tablespoon at room temperature, nearly melting
- Piece of foil, approximately 4" x 8"
- Container with ice (for Extension Challenge)

Lab Station 5: Heat on Water (Radiation)

- Heat lamp or lamp with 150 watt bulb
- Small cup of water at room temperature
- Thermometer

Lab Station 6: Thermal Blanket (Radiation)

- Space blanket (with reflective side marked)
- Heat lamp or lamp with 150 watt bulb

Teacher Materials

- Student Participation Observations form
- Stamp (to record student participation)

Task 3: Insulators and Conductors

Part II: Insulators and Conductors Experiment

Student Materials (for each group)

- 4 containers of hot water, 500 mL each (Alternatively, students could use insulated take-out coffee cups with covers. This eliminates the need to cover cups with plastic wrap. Also, students could use two containers at a time and do the experiment two times to get all the data.)
- Plastic wrap or tops for the containers
- Thermometer
- Timer
- Masking or Scotch tape
- A variety of materials, such as the following:
    - Aluminum foil
    - Shredded or crumpled newspaper
    - Cardboard
    - Plastic bags
    - Cloth (e.g., cotton or wool)
    - Foam

(Note: You may want to ask students to bring items from home.)

Part III: Design an Insulating or Conducting Experiment Using an Ice Pop

Student Materials (for each group)

- Ice pops
- The same materials as in Part II: Insulators and Conductors Experiment
- Additional materials students need for their device design (ask students to bring in the items)
- Masking or Scotch tape

Teacher Materials

- Student Participant Observations form
- Stamp (to record student participation)

Task 4: Mass and Thermal Energy

Student Materials (for each group)

- 2 cups cooked instant oatmeal
- 3 beakers or plastic bowls large enough to hold 1 cup of oatmeal (do not use polystyrene foam or insulated cups)
- 3 thermometers
- Timer
- Graph paper or large piece of poster paper
- Measuring cups for oatmeal (1 cup, $\frac{1}{2}$ cup, $\frac{1}{4}$ cup)

Teacher Materials

- *Goldilocks and the Three Bears*
- Hot plate or slow cooker to keep oatmeal hot
- Cooked oatmeal (enough for 2 cups per group)