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HARNESSING SOLAR ENERGY LESSON PLANS

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Lesson Plan 1: Energetic Interactions

This lesson introduces the concepts of energy as the ability to do work, energy transformations, and potential and kinetic energy. It also presents the concept of scarce resources as an introduction to the module's final challenge, the Water for All Challenge, in which student teams will design solar-powered devices to address water scarcity. Students learn about the engineering design process (EDP) and are challenged to use this process to create a marshmallow launcher that exhibits energy transformations.

ESSENTIAL QUESTIONS

- What is energy?
- How do we use energy?
- What is scarcity?
- How does scarcity apply to natural resources such as water?
- What is the EDP, and how can we use it to create a solution to a problem?

ESTABLISHED GOALS AND OBJECTIVES

At the conclusion of this lesson, students will be able to do the following:

- Identify examples of energy and define energy as the ability to do work
- Provide examples of potential and kinetic energy
- Demonstrate transformations of potential to kinetic energy
- Apply their understanding of potential and kinetic energy and the EDP to design a device that demonstrates transformations from potential to kinetic energy

- Use their understanding of the concept of scarcity to discuss resource scarcity and identify geographic areas with water scarcity
- Use maps to identify areas with water scarcity and understand geographic features of these regions

TIME REQUIRED

- 4 days (approximately 45 minutes each day; see Table 3.6, p. 39)

MATERIALS

Necessary Materials for Lesson 1

- Internet access to show videos
- STEM Research Notebooks (1 per student; see p. 26 for STEM Research Notebook student handout)
- Chart paper
- *The Boy Who Harnessed the Wind*, Young Readers' Edition, by William Kamkwamba and Bryan Mealer
- *The Magic School Bus and the Electric Field Trip* by Joanna Cole
- *Charged Up: The Story of Electricity* by Jacqui Bailey
- 100-inch-long strip of paper

Additional Materials for Popcorn for All

- Popped popcorn (enough to fill about 3 lunch bags)
- 12 paper lunch bags
- 5 oz. paper cups (1 per student)

Additional Materials for You've Got Potential (per group of 3–4 students unless otherwise indicated)

- Ball (1 per class)
- 4 strips of cardboard (each 2 feet long)
- 4 chairs
- Waxed paper
- Masking tape

- 8 pennies or small metal washers
- Cup of water
- Small piece of butter or cooking spray
- You've Got Potential Instructions and Data Sheet handouts (1 set per student; attached at the end of this lesson)

Additional Materials for the Marshmallow Mile

- Safety glasses or goggles
- 10 craft sticks
- 8 nonlatex rubber bands
- 2 plastic spoons
- Scissors
- Marshmallows (regular size)
- Masking tape
- The Marshmallow Mile and EDP graphic handout (1 set per student; attached at the end of this lesson)
- Paper plates or cups, or both

Additional Materials for That's the Way the Cookie Crumbles

- 12-inch or larger cookie, pie, cake, or pizza (large enough to provide slices for all students)
- 2 paper circles (same size as cookie, pie, cake, or pizza)
- World Water Scarcity Map handout (1 per student; attached at the end of this lesson)

SAFETY NOTES

1. All laboratory occupants must wear safety glasses or goggles during all phases of this inquiry activity.
2. Immediately wipe up any water on the floor to avoid a slip-and-fall hazard.
3. Do not eat any food used during this investigation.

Table 4.2. Key Vocabulary in Lesson 1

Key Vocabulary	Definition
collaboration	the act of working together in groups to achieve a goal or create something
desalination	removal of salt and minerals from seawater so that it can be used as drinking water
electromagnetic radiation	a form of energy that travels in waves, such as the energy of the Sun and other light, radio waves, X-rays, and microwaves
energy	the ability to do work; a force that has the power to make things move or change
kinetic energy	the energy of an object in motion
natural resources	substances that occur in nature and that may be used to make other products
percentage	the amount of something in each hundred
potential energy	energy that is stored in an object because of its position
scarcity	the state of something being in short supply
solar energy	the energy that comes from the Sun; it is felt as heat, or thermal energy
speed	distance traveled in a certain amount of time; the rate at which something moves
thermal energy	energy that can be transferred from one object to another as heat
water scarcity	the condition where there are not enough water resources to meet the needs of a geographic area; affects every continent on Earth
work	what occurs when a force applied to an object moves the object; energy is transferred from one object to another

TEACHER BACKGROUND INFORMATION

Energy

The classic definition of energy, the ability to do work, may be difficult for students to conceptualize. Energy may also be conceptualized as a physical property of objects, which may be a more accessible concept for fourth-grade students. However, unlike other physical properties such as color and mass, energy is better understood by what it can do, rather than how it looks or feels, so in this book, energy is defined as the ability to do work. The concept of work is important for students to understand as a precursor to understanding the definition of energy. Students may consider work to be anything that requires effort, such as studying or washing dishes. Although some of these activities meet the scientific definition of work (applying a force to move an object), students need to understand that work involves a transfer of energy from one object to another.

All energy falls into two major categories: potential and kinetic. Although there are various forms of potential energy (e.g., chemical, gravitational, elastic, electric, and nuclear), students at this level should understand that potential energy is energy that is stored because of an object's position. Likewise, there are various forms of kinetic energy. Students have experience with various forms of kinetic energy (e.g., mechanical, radiant, thermal, sound, and electrical), and you may choose to introduce these types of energy in more detail.

Students may confuse primary energy sources with energy carriers. Electricity is an examples of an energy carrier, or secondary energy source, since it is made from the conversion of primary sources of energy (e.g., coal, nuclear, or solar energy).

Water Scarcity

Water scarcity is an issue of interest both in the United States and globally. The 2012 World Water Day video about water scarcity provides an overview of world water availability. Visit YouTube and search for "Water, the World Water Crisis" or access the video directly at *www.youtube.com/watch?v=iRGZOCaD9sQ*. (*Note:* This video contains material that is not appropriate for students in this grade level, such as references to children dying from water-related causes; if you do choose to share portions of the video with students, it is recommended that you stop at 2:40.) According to the United Nations (*www.un.org/waterforlifedecade/scarcity.shtml*), around 1.2 billion people, about one-fifth of the world's population, live with water scarcity. Although there is enough water on the planet for everyone, it is distributed unevenly.

Engineering

Students begin to gain an understanding of engineering and other professions related to resource use in this module. In particular, they should understand that engineers are people who design and build products in response to human needs. Engineers apply science and math knowledge to create these designs and solutions. Students should also understand that there are many different types of engineers. For an overview of the various types of engineering professions, see the following websites:

- *www.engineeryourlife.org/?ID=6168*
- *www.nacme.org/types-of-engineering*
- *www.sciencekids.co.nz/sciencefacts/engineering/typesofengineeringjobs.html*

Career Connections

As career connections related to this lesson, you may wish to introduce the following:

- *Urban planner:* Urban planners work to optimize the effectiveness of a community's land use by developing plans to create communities and plan for growth.

- *Geographer:* Geographers study the Earth's natural land formations and human society, with a focus on the relationship between these phenomena. In particular, they study the characteristics of various parts of the Earth, including physical characteristics and human culture. Many geographers work for the federal government. Teaching and field research are other areas in which geographers work. For more information, see *www.bls.gov/ooh/life-physical-and-social-science/geographers.htm.*
- *Mechanical engineer:* Mechanical engineers design and build mechanical systems (such as motors) and tools.
- *Electrical engineer:* Electrical engineers design electrical circuits and computer chips.
- *Civil engineer:* Civil engineers design bridges, roads, and dams.
- *Computer engineer:* Computer engineers do work that is similar to that of electrical engineers, but they specialize in computer technology. Much of their work with electrical circuits is on a very small scale, such as in microprocessors.

Engineering Design Process (EDP)

Students should understand that engineers need to work in groups to accomplish their work, and that collaboration is important for designing solutions to problems. In this module, students are challenged to work in teams to complete a variety of tasks and to act as design engineers. They will use the engineering design process (EDP), the same process that professional engineers use in their work. Your students may be familiar with the scientific method but may not have experience with the EDP. Students should understand that the processes are similar but are used in different situations. The scientific method is used to test predictions and explanations about the world. The EDP, on the other hand, is used to create a solution to a problem. In reality, engineers use both processes and your students' experience will reflect this. A good summary of the similarities and differences between the processes can be found at *www.sciencebuddies.org/engineering-design-process/engineering-design-compare-scientific-method.shtml*. An additional resource about the EDP is *www.pbslearningmedia.org/resource/phy03.sci.engin.design.desprocess/what-is-the-design-process.*

A graphic representation of the EDP is provided at the end of this lesson (p. 73). It may be useful to post this in your classroom. You should be prepared to review each step of the EDP listed on the graphic with students.

COMMON MISCONCEPTIONS

Students will have various types of prior knowledge about the concepts introduced in this lesson. Table 4.3 (p. 54) outlines some common misconceptions students may have concerning these concepts. Because of the breadth of students' experiences, it is not possible to anticipate every misconception that students may bring as they approach this lesson. Incorrect or inaccurate prior understanding of concepts can influence student learning in the future, however, so it is important to be alert to misconceptions such as those presented in the table.

Table 4.3. Common Misconceptions About the Concepts in Lesson 1

Topic	Student Misconception	Explanation
Energy	Gravitational potential energy depends only on the height of an object.	Gravitational potential energy depends on both an object's position (its height above Earth) and its mass.
	Gravitational potential energy is the only type of potential energy.	Potential energy is energy that is stored in some way. While it may be stored in its position or height (gravitational potential energy), it can also be stored in the form of elastic potential energy (for example, a compressed string or stretched rubber band) or chemical potential energy (the energy stored in chemical bonds).
Engineering design process (EDP)	Engineers use only the scientific process to solve problems in their work.	The scientific method is used to test predictions and explanations about the world. The EDP, on the other hand, is used to create a solution to a problem. In reality, engineers use both processes.
Work	Work is anything that requires effort by a person.	Work occurs when a force moves an object over a distance; work transfers energy from one object to another object. When you hold a brick above the ground, for example, your arm may become tired, but you are not doing work just by holding the brick. Work does not need to involve a person.

PREPARATION FOR LESSON 1

Review the Teacher Background Information provided, assemble the materials for the lesson, duplicate the student handouts, and preview the videos recommended in the Learning Plan Components section below. Have your students set up their STEM Research Notebooks (see pp. 25–26 for discussion and student instruction handout).

For the Popcorn for All activity, fill 3 paper lunch bags with popped popcorn (enough for about half the class) and fill 3 more lunch bags with crumpled paper bags. Fold over the tops of the bags so that students cannot see the contents.

If you choose to have a launcher competition in the Marshmallow Mile activity, you will need some way to measure marshmallow flight distances. You can do this by affixing masking tape lines on the floor or placing paper plates or cups at various distances from students' launchers. You may wish to mark each with a point value, with the farthest