Understanding the Mechanics of Solar Technology

Teacher Activity

BACKGROUND

Though the term "technology" often has the connotation of being sophisticated and complex, solar technology can actually be quite simple. Light energy can be converted through a series of transformations into mechanical energy. So how does this process work?

OBJECTIVES

In this activity, students will investigate the factors that influence the speed and pattern of movement in simple solar toys. After hypothesizing the internal mechanism that moves the toy, students will dissect the toy to further examine its inner workings and determine the types of energy transformations that occur.

After completing this investigation, students will be able to:

- Explain the effects of various factors on the functioning of a solar toy.
- Describe the mechanism of how a solar toy works.
- Identify the types of energy transformations that occur in a solar toy.

GRADE LEVELS – 7-12 Science

TIME REQUIRED – 2 class periods (one part each day)

MATERIALS PER STUDENT OR GROUP

- simple solar toy – flower, animal, plane, etc. (often found at a dollar store)
- small LED flashlight
- forceps
- other materials that may be involved in student-designed investigations: timer, calculator, ruler, colored gel sheets (found at craft stores or available online)

* *It is suggested that students use a pencil to make drawings and add labels. One additional color (or even a pen) may be helpful to color-code labels.*

* *The quality of the solar toys dictates how long they can be reused. Field testing results suggest that basic solar toys can be reassembled and reused 3-5 times before needing to be replaced; however, that range will vary depending on the grade level of the student and their care of the toy.*

ALIGNMENT

Next Generation Science Standards

DCI: Conservation of Energy and Energy Transfer (PS3.B)
DCI: Relationship between Energy and Forces (PS3.C)
SEP: Planning and Carrying Out Investigations
CC: Energy and Matter

Energy Literacy Principles

#1.1, 1.3, 1.4, 1.5 Energy is a physical quantity that follows precise natural laws.
#4.1 Various sources of energy can be used to power human activities, and often this energy must be transferred from source to destination.

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ALIGNMENT (*cont'd*)

Ohio's Model Science Curriculum

Grade 7 Physical Science:	Energy can be transformed or transferred but is never lost.
High School Physics:	Conservation of Energy
High School Environmental Science:	Earth's Resources

PRIOR TO THE LESSON

1. Print and cut apart enough investigative questions for each group to have one. Some groups may have the same question if there are more than 9 groups. These can be reused for multiple classes or multiple years.
2. Print enough Solar Mechanics Terminology Lists for each group to have one. These can be reused for multiple classes or multiple years.
3. Compile sets of materials. Each group should have a solar toy, flashlight, and forceps. Other materials can be placed in a central location for students to use as needed.

Lesson

ENGAGE

Show the following video (***go.osu.edu/solartoys***) of dancing solar toys as students enter the room and get ready for class.

EXPLORE & EXPLAIN

Students should have prior understanding of types of energy and transformations. A quick poll or quiz using Nearpod can easily elicit students' background knowledge.

PART 1: TO WHAT EXTENT DO VARIOUS FACTORS AFFECT THE MOVEMENT OF A SOLAR TOY?

1. Have each group draw an investigative question out of a bowl.
2. Students will design an experiment and collect data to answer their assigned question.
3. Use the instructions on the student page to guide students through the process of designing and carrying out their own investigation.
4. Have student groups share their findings with the class before moving on to Part 2.

Teacher's Note:
This activity is designed as a minimally guided or open inquiry investigation. It can be modified to be a structured inquiry lesson. Teachers can provide a set procedure for students to follow or a data table for students to use if scaffolding or additional structure is needed.

PART 2: HOW DO THE COMPONENTS OF A SOLAR TOY MAKE IT MOVE?

1. Now that students have investigated what factors affect the movement of a solar toy, discuss the types of energy transformations that might be occurring within it.
2. Students then hypothesize how the internal components of the toy might be arranged. They are asked to label the parts they draw to the best of their ability. At this point, the emphasis is on the function of the part rather than the technical name. Example: "This piece must hold the electricity from the solar panel."

This is a checkpoint for formative assessment; teachers should look at students' drawings and initial the paper before students proceed.

3. Next students confirm or revise their hypotheses by carefully opening the solar toy to see the components and their arrangement. There is space for the student to draw what they actually see. This time, however, students are asked to assign labels to the components even if they are not positive of the terms or what they mean. Encourage students to write labels in pencil.
   * *The teacher can perform the solar toy "dissection" as a demonstration using a document camera projecting the process so all students can see. Note, however, that this strategy will limit the exploration and conceptual understanding by students.*

This is a checkpoint for formative assessment; teachers should look at students' drawings and labels and initial the paper before providing students with the Solar Mechanics Terminology List.

4. Once students have the terminology list they can correct labels as needed. Using a different color writing utensil, they can also identify the energy transformations that are happening inside the toy.

ELABORATE

Successful completion of this activity prepares students to apply the acquired knowledge and skills in future activities where they must design technological/engineering solutions using science concepts (highest level of cognitive demand in Ohio's Model Science Curriculum). Many activities exist online that have students construct a car or creature that uses solar energy to produce movement.

Solar Kit Lessons: A compendium of solar energy resources for middle school students.
www.nrel.gov/education/pdfs/nesea_solar_kit_lessons.pdf

Solar Car Project: How to build a mini solar car with simple materials
www.xof1.com/buildMiniSolarCar.php

EVALUATE

Assessment tasks are built into the student page. Question 4 in Part 1 and questions 7 and 8 in Part 2 require students to demonstrate science knowledge (second highest level of cognitive demand in Ohio's Model Science Curriculum).

Selected Answers to Student Worksheet

PART 1

Answers will vary for all questions.

PART 2

1-6. Answers will vary.

7. light → electric energy in photovoltaic cell, electric energy → magnetic energy in voice coil, magnetic energy → mechanical energy in magnet/pendulum

8. The solar toy moves when the photovoltaic cell is activated. The light energy is converted to electricity which is stored in the capacitor. The electrical board brings the wire from the photovoltaic cell in contact with the wire from the voice coil. Pulses of electric current then move down the voice coil (made of copper) creating a magnetic field. The pulses in the magnetic field pull the magnet toward the coil. The magnet is attached to a pendulum which moves the lever arms making the solar toy "dance."

FINAL QUESTIONS

1. Answers will vary, but the dependent variable will likely be the movement or speed of the solar toy.
2. F, E, D, A, C, B
3. Answers will vary.
4. No energy transformation is 100% efficient. Some energy will always be converted into heat.

SOURCE

Solar Energy Curriculum Consortium

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Solar Mechanics Terminology List

Component	Function
Capacitor	a two-terminal electrical component used to temporarily store electrical energy
Electrical board	backboard for holding wires close to each other
Magnet	attracted to a magnetic field thus moving the level arm to which it is attached
Pendulum	weight suspended from a pivot so that it can swing freely
Photovoltaic (PV) cell	device that converts energy from light directly into electricity
Voice coil	provides a conduit for electrical energy; a magnetic field is generated along its axis

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Investigative Question 1:
How does distance of light affect the movement of the toy?

Investigative Question 2:
How does light intensity affect the movement of the toy?

Investigative Question 3:
How does the angle of light affect the movement of the toy?

Investigative Question 4:
How does the color of light affect the movement of the toy?

Investigative Question 5:
What color of light results in the fastest movement of the toy?

Investigative Question 6:
What angle of light results in the fastest movement of the toy?

Investigative Question 7:
What distance of light results in the fastest movement of the toy?

Investigative Question 8:
What intensity of light results in the fastest movement of the toy?

Investigative Question 9:
Does natural light or artificial light have a greater effect on the movement of the toy?

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Student Activity

Name _____

BACKGROUND

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In this activity, you will investigate the factors that influence the speed and pattern of movement in simple solar toys. After hypothesizing the internal mechanism that moves the toy, you will dissect the toy further examine its inner workings and determine the types of energy transformations that occur.

PROCEDURE

PART 1: TO WHAT EXTENT DO VARIOUS FACTORS AFFECT THE MOVEMENT OF A SOLAR TOY?

1. Choose an investigative question from your teacher. Write your question in the space below.

2. Use the space below to write the procedure you will use to collect data to answer the question.

   What variable is being tested in your experiment? _____

3. What data will you collect? Use the space below to construct a data table.

   What variable is being measured in your experiment? _____

4. Write a conclusion that answers the investigative question. Be sure to use evidence to justify your statement.

PART 2: HOW DO THE COMPONENTS OF A SOLAR TOY MAKE IT MOVE?

You've explored WHAT external factors affect solar toy movement, now hypothesize HOW it moves. What's the pathway from light to movement? Keep in mind that movement happens without plugging anything into an electrical outlet or flipping a switch.

1. Make a list of the possible energy transformations that are likely happening to make the toy move.

2. Draw what you envision the inside of the solar toy looks like. Label the components you draw by describing what they must do; don't feel like you have to know the proper names of the parts. Show your drawing to your teacher before proceeding.

   _____ teacher initials

3. Carefully begin to dissect the solar toy. Delicately remove the outer shell without disassembling the internal components. The forceps may help you move the tiny components.

4. Use this space to create a drawing of the pathway of components that ultimately make the toy move.

5. USING A PENCIL, label the drawing above with the following terms. Use your background knowledge and consider what the terms might mean to do your best job at labeling the drawing. Show your drawing and labels to your teacher before proceeding.

   capacitor **photovoltaic cell** **voice coil** **magnet** **electrical board** **pendulum**

   _____ teacher initials

6. Now that you know about the function of each component fix any labels that were originally incorrect.

7. Look back at the first question in this section. Now make a complete and accurate list of all the energy transformations that must happen to make the toy move.

8. Demonstrate your understanding by answering the original question:
How do the components of a solar toy make it move?

   Write your answer as a complete paragraph that lists all of the components, discusses the components' functions, and identifies where energy transformations are occurring. Use your answers from questions 5-7 to help frame your paragraph.

Use good writing conventions as this is the most important part of the activity.

FINAL QUESTIONS

What makes a solar toy move?

1. Identify the variables in your investigation:

   Independent: _____ Dependent: _____

2. Match the components of a solar toy with its function

_____ electrical board	a. transmits an electric current that creates a magnetic field
_____ capacitor	b. moves a pendulum as it is attracted to a magnetic field
_____ pendulum	c. converts light energy to electricity
_____ voice coil	d. moves the “dancing” parts of a solar toy
_____ photovoltaic cell	e. stores electrical energy
_____ magnet	f. holds wires close together

3. Use this space to draw a diagram or flow chart of all the energy transformations that occurred to make the toy move. Be sure to label each type of energy in your drawing.

4. Are the energy transformations 100% efficient? Explain your answer.