Nasco Education

LESSON PLAN

STEM/ STEAM

Developed with California Sunlight

Volume 20 | Gr. 3–12

Energy conversion: Optical to thermal

Materials list

- Solar Balloon Energy Kit(s) (**SB52005**)
- Digital laboratory thermometer (**SB33552**)
- Measuring cup (**WA29913**)
- Graph paper, 8½" x 11" (**9706099**)
- Stirling engine (**SB49166**)
- PocketLab Weather Sensor (**NA10341**)
- Hot pad for handling pan (**SB01889**)
- Water

Objectives

Students will...

- Learn different forms of energy (optical, thermal, mechanical, electrical)
- Learn that energy may be converted from one form to another
- Study the energy conservation law
- Understand there may be losses converting energy from one form to other forms
- Build a solar cooker based on the Solar Balloon Energy Kit
- Heat 1 cup of water to 200° F or higher using the Solar Balloon Kit
- Calculate the efficiency of the Solar Balloon in converting sunlight to heat
- Use the hot water to drive a Stirling engine
- Estimate the efficiency of the Stirling engine
- Apply critical thinking to energy conversion
- Experience team building and real-world problem solving

1. Introduction

Students study the different forms of energy, such as optical, thermal, mechanical, and electrical energy. Energy may be converted from one form to another form (or forms) based on the energy conservation law. However, there may be losses when energy is converted from one form to another. This does not mean that some energy disappeared; it means part of the energy is converted to different forms. Students will use the Solar Balloon Energy Kit to build a solar cooker to convert optical energy (sunlight) to thermal energy (hot water). Then they will use the hot water to drive a Stirling engine to convert the thermal energy to mechanical energy. Students will estimate or discuss the efficiency of each energy conversion.

Optional: Students can use a generator to convert the mechanical energy to electrical energy.

2. Build a solar cooker

Based on the number of students in the class and the available Solar Balloon Energy Kits, divide students into several groups. Each group has one Solar Balloon Energy Kit. Each group of students will build a solar cooker according to the instructions that come with the energy kits. Encourage students to be creative. Younger students may need more guidance.

3. Converting optical energy to heat (Choose a sunny or partially sunny day)

Each group of students use the PocketLab Weather Sensor to measure sunlight intensity. Record the time of the measurement and the sunlight intensity. Use the measuring cup to add 1 cup of water to the black cooking pan. Use the digital thermometer to measure the temperature of the water in the black pan. Record the time of the measurement and the water temperature. Put the black pan with water into the cooking sleeve under the small end of the balloon. Orient the balloon toward the sun. Measure and record the temperature of water in the black pan, and the ambient temperature every 2 minutes until water temperature reaches 200° F. Plot the water temperature and the ambient temperature as a function of the time on the graph paper. Calculate the total solar energy entering the balloon (S) and the energy needed to heat water from ambient temperature to 200° F (Q). Then, calculate the efficiency of the solar cooker in converting optical energy (sunlight) to thermal energy (heat in hot water). It should be Q/S.

4. Converting thermal energy to mechanical energy

Students will use the hot water from the solar cooker to drive a Stirling engine. Discuss the efficiency of the Stirling engine in converting the thermal energy in the hot water to mechanical energy.

5. Converting mechanical energy to electrical energy (optional)

Students may attach a generator to the Stirling engine to convert the mechanical energy to electric energy.

Assessment

Teacher observation, participation in activities, cooperation, handling materials, participation in oral discussion, completeness of projects, written work, and illustrations.