SOLAR ENERGY

CONVERTING RADIANT ENERGY TO HEAT

JILL WILLIAMS

Time Frame:	Standards:
45-60 minutes	8-9.PS(ES).1.2.1 Use observations and data as evidence on which to base scientific explanations 8-9.PS(ES).1.6.3 Use appropriate technology and mathematics to make investigations. 8-9.PS.2.3.2 Classify energy as potential and/or kinetic and as energy contained in a field 7.S.1.2.2 Use observations to make defendable inferences 7.S.1.6.2 Use appropriate tools and techniques to gather and display data 7.S.1.6.3 Evaluate data in order to form conclusions 7.S.1.6.4 Use evidence and critical thinking to accept or reject a hypothesis

Objectives:

To demonstrate that radiant energy can be absorbed or reflected by objects. Some of the energy absorbed by objects is converted into heat.
THIS ACTIVITY NEEDS TO BE DONE ON A SUNNY OR PARTLY SUNNY DAY!!

Background Information:

When energy hits objects it can be reflected or absorbed. The absorbed radiant energy can be converted into heat (thermal energy). Black objects tend to absorb radiant energy. Shiny objects tend to reflect radiant energy. Radiant energy can be by the sun or by an artificial source.

What is energy?

Energy is the ability to do work, the ability to make a change. Everything that happens in the world involves a change of some kind, the exchange of energy in some way. The total amount of energy in the universe remains the same. When we use energy, we do not "use it up"; we convert one form of energy into other forms. Usually the conversion of energy produces some heat, which is considered the lowest form of energy, since it dissipates into the surroundings and is difficult to capture and use again. Energy is categorized in many ways: the forms it takes and by what it does, the changes it makes, the effects we can see, feel, or measure.

What Energy Does: Energy is recognized in the following ways:

- Energy is light: energy produces light- the movement of energy in transverse electromagnetic waves-radiant energy.
- Energy is heat: energy produces heat-the movement of atoms and molecules within

substances-thermal energy.
- Energy is sound: energy produces sound-the back-and-forth vibration of substances in longitudinal waves.
- Energy is motion: energy produces motion-kinetic energy.
- Energy is growth: energy is required for cells to reproduce-chemical energy stored in the bonds of nutrients.
- Energy is electricity to run technology: the movement of electrons from atom to atom.

Forms of Energy: Energy is recognized in many forms, all of which are potential or kinetic:

- Thermal Energy (Heat)
- Mechanical Energy (Motion)
- Chemical Energy (Energy in Wood, Fossil Fuels)
- Electrical Energy (Electricity, Lightning)
- Nuclear Energy (Fission, Fusion)
- Radiant Energy (Visible light, X-rays, Microwaves)
- Sound (Motion)

Solar Energy

Solar energy is energy from the sun. The sun is a giant ball of hydrogen and helium gas. The enormous heat and pressure in the interior of the sun causes the nuclei of two hydrogen atoms to fuse, producing one helium atom in a process called fusion. During fusion, nuclear energy is converted into thermal (heat) energy and radiant energy. The radiant energy is emitted from the sun in all directions and some of it reaches Earth. Radiant energy is energy that travels in electromagnetic waves or rays. Radiant energy includes visible light, x-rays, infrared rays, microwaves, gamma rays, and others. These rays have different amounts of energy depending upon their wavelength. The shorter the wavelength, the more energy they contain.

Information is from The NEED Project in the Exploring Solar Energy Teacher guide
http://www.need.org/

Materials:

- 10 cans – 5 painted black, 5 regular metal. Soup size is about right or pint size paint cans. Talk to your cafeteria about soup cans that they throw away.
- 10 lids with holes for the rubber stoppers. If you buy pint sized paint cans they come with lids. You can drill a hole in the lid the right size for the stoppers.
- 10 rubber stoppers (The kind with the hole in the middle to put the thermometer through.)
- 10 thermometers
- Pitchers of hot water
- Pitchers of cold water
- 1 - 5 Overhead projectors or heat lamps (To make this activity easier, have several overhead projectors or heat lamps if possible. It works much better.)

- 5 beakers (For measuring the hot and cold water into the cans.)
- Classroom set of Lab sheet or Individual Lab sheet (examples below)

Procedure:

1. **Prep:** Paint 5 cans and lids black. Drill holes in center just smaller than the size of the stopper. Your wood shop or tech teacher may be able to help with this.
2. **Prep:** Before the students arrive in class create 5 centers. At each center have 2 cans (1 black, 1 silver), the lids and stoppers to go with, 2 thermometers, and if possible more than 1 artificial light source. If it isn't possible rotate the groups using the light source so not all groups are there at once. Have hot and cold water ready for your classes.
3. **Activity:** Introduce students to the idea that radiant energy can be absorbed or reflected and that some things absorb more radiant energy than others.
4. Break the students up into 5 groups. Assign each group a center. Go over the procedures for the lab.
5. Have them start by inserting the thermometers into the cans and positioning the stoppers so the thermometers don't touch the bottom. Record the temperature in both Fahrenheit and Celsius on data table.
6. Place the cans under the artificial light(s). Record the temperature after 5 minutes.
7. Open the cans and allow the air inside to return to the original temperature.
8. Take the students outside to a sunny location. Have them set their cans down in the sun. Have the students predict what will happen. After five minutes, record the temperatures of the cans. (You can also place them in a sunny position in the classroom if you have windows.)
9. Open the cans and allow the air inside to return to the original temperature.
10. Fill both of the cans with 200 ml of cold water and record the temperatures. Place the cans in a sunny place. Predict what will happen. Record the temperatures after 5 minutes.
11. Fill both of the cans with 200 ml of hot water and record the temperatures. Place the cans in a sunny place. Predict what will happen. Record the temperatures after 5 minutes.
12. Have the students look at their data table and answer the questions.
13. Discuss the group conclusions as a class. Have the students turn in their lab sheets and answers to the questions.

Assessment:

Assessments are based on the students' data and conclusions from the lab sheet. Does the information in their data table lead to logical conclusions? Were they able to complete the lab as outlined on the lab sheet?

Additional Content:

You may use the following lab sheets for this lab or you can create your own.

RADIATION CANS

When radiant energy hits objects, some of the energy is reflected and some is absorbed and converted into heat. Some objects absorb more radiant energy than others.

PURPOSE: To explore the conversion of radiant energy into heat.

PROCEDURE:

Step 1: Put thermometers into the black and silver cans and position the stoppers so they are not touching the bottom of the cans. Record the temperatures of both the cans in Celsius and Fahrenheit.

Step 2: Place the cans under the bright artificial light, such as an overhead projector or heat lamp. Predict what will happen. Record the temperature of both cans after 5 minutes.

Step 3: Open the cans and allow the air inside to return to the original temperature. Place the cans in a sunny place. Predict what will happen. Record the temperatures of both cans after 5 minutes.

Step 4: Using your beaker, measure out 200 ml of cold water. Pour 200 ml of cold water into each can. Record the temperatures. Place the cans in a sunny place. Predict what will happen. Record the temperatures after 5 minutes. Dump out the water.

Step 5: Using your beaker, measure out 200 ml of hot water. Pour 200 ml of hot water into each can. Record the temperatures. Place the cans in a sunny place. Predict what will happen. Record the temperatures after 5 minutes. Dump out the water.

RECORD THE DATA

	AIR						COLD WATER				HOT WATER			
	ORIGINAL		SUN 5 MIN		LIGHT 5 MIN		ORIGINAL		SUN 5 MIN		ORIGINAL		SUN 5 MIN	
	C	F	C	F	C	F	C	F	C	F	C	F	C	F
BLACK CAN														
SILVER CAN														

CONCLUSIONS: Look at your data. What have you learned about converting radiant energy into heat? About reflection and absorption of radiant energy?

1. Silver and black cans:
2. Solar and artificial light:
3. Air and water:
4. Cold and hot water:

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PURPOSE: To explore the conversion of radiant energy into heat.

PROCEDURE:
Step 1: Put thermometers into the black and silver cans and position the stoppers so they are not touching the bottom of the cans. Record the temperatures of both the cans on the data table you create.
Step 2: Place the cans under the bright artificial light, such as an overhead projector or heat lamp. Predict what will happen. Record the temperature of both cans after 5 minutes.
Step 3: Open the cans and allow the air inside to return to the original temperature. Place the cans in a sunny place. Predict what will happen. Record the temperatures of both cans after 5 minutes.
Step 4: Using your beaker, measure out 200 ml of cold water. Pour 200 ml of cold water into each can. Record the temperatures. Place the cans in a sunny place. Predict what will happen. Record the temperatures after 5 minutes. Dump out the water.
Step 5: Using your beaker, measure out 200 ml of hot water. Pour 200 ml of hot water into each can. Record the temperatures. Place the cans in a sunny place. Predict what will happen. Record the temperatures after 5 minutes. Dump out the water.

CONCLUSIONS: Look at you data. What have you learned about converting radiant energy into heat? About reflection and absorption of radiant energy?

5. Silver and black cans:

6. Solar and artificial light:

7. Air and water:

8. Cold and hot water:

References:

Adapted from The NEED Project's 2008 Exploring Solar Energy Activity 2
http://www.need.org/
Adapted by Jill Williams as part of the INL Educational Science writing team.