Drexel-SDP GK-12 ACTIVITY

Subject Area(s): Solar Energy**,** Scientific Method

Associated Unit: None

Lesson Title: Build Your Own Solar Water Heater

Header Insert Image 1 here, right justified to wrap

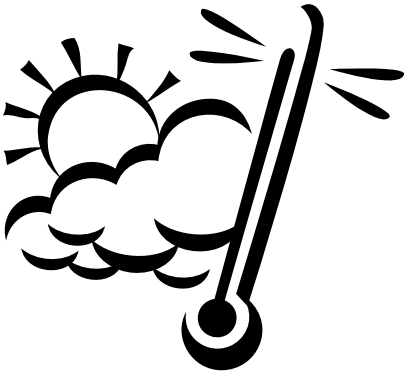


Image 1

Description: Black and white drawing of the peaking out of a cloud with a thermometer in the foreground

Source/Rights: Microsoft Clip Art

Image 2

Description: Cartoon picture of a sun with a smiley face

Source/Rights: Microsoft Clip Art

Grade Level 5

Lesson # 1 of 1

Time required: 3 hours

Summary

Students will design and build their own solar water heaters. They will utilize the scientific method to formulate hypothesis and verify their predictions. Their designs will be tested against one another to determine which water heater is capable of heating up water the fastest.

Engineering Connection

Engineers must work to find alternative sources of energy. The most abundant and most wasted energy resource is the sun. This lesson will utilize engineering skills to develop a better way to use the suns energy to heat water.

Keywords

Solar energy, solar water heater, scientific method

Educational Standards

- Science: 3.1.7, 3.2.7, 3.4.7, 3.7.7, 3.8.7
- Math: 2.6, 2.4C, graphing

Pre-Requisite Knowledge

Learning Objectives

After this lesson, students should be able to:

- Develop hypothesis and test them
- Understand how changes in height and tube diameter can effect flow rate
- Develop ways to translate solar energy (i.e. light) into heat
- Utilize the scientific method to influence there design
- Understand the design process and have a better understanding of engineering tasks
- Understand and develop ways to capture the suns energy

Introduction / Motivation

Could you imagine taking a shower and/or bath without hot water? Have you ever wondered where hot water comes from? Most of us have some sort of water heater (usually located in the basement) that heats our water by either gas or electricity. Resources that go into making electricity or the products released from burning gas are a major cause of the deteriorating environment. Energy from the sun is a valuable resource that goes almost completely unused as an alternative to electricity or gas.

Lesson Background & Concepts for Teachers

Designing a water heater that produces the greatest temperature increase must maximize the amount of time that the water is exposed to the light and concentrate the suns rays on the water. Maximizing the amount of time the water is exposed to the light is done primarily by

decreasing the water flow rate and by increasing the number of passes that the water makes under the light. Decreased the flow rate can be performed by limiting the height differential between water inlet and outlet (i.e. limiting the affects of gravity) and by 'kinking' the tubing. Increasing the number of passes can be done by putting a number of U-shaped bends in the tubing so that the tubing passes back and forth under the light or by simply taking water from the outlet and pouring it into the inlet as fast as possible. Concentrating the suns rays on the light is performed by allowing the tubing to pass through toilet paper or paper towels rolls that are cut in half and covered in a reflective material like tin foil.

Also, the tubing should be black b/c black absorbs all of the colors in the light spectrum causing things that are black to heat up the most as compared to other colors.

Vocabulary / Definitions

Word	Definition
Flow rate	Amount of water divided by time
Variables	Things that are likely to vary
Control variable	Variables that are kept constant
Dependent variable	Variable that we measure
Independent variable	Variable that we change

Associated Activities

Materials

Materials for Both

- Tubing (aquarium tubing), black is suggested b/c painting clear tubing may prove messy
- Paper towel or toilet paper tolls
- Aluminum foil
- Desk lamps (one per group)
- Extension cords (if necessary)
- Wood, crates, books, etc. (something to set various parts of their water heaters on so that the inlet is higher than the outlet)
- Jars/cups for collecting water
- Non-mercury thermometer

Economy Version

- Styrofoam or paper cups
- Poster putty (need some type of putty to create a water tight seal between the tubing and the cup)

Scaled-up Version

- Drill with drill bits
- Some sort of wrench to tighten the brass adapter into the PVC plug
- 4” PVC Cleanout Plug ($1.66 each at Home Depot)

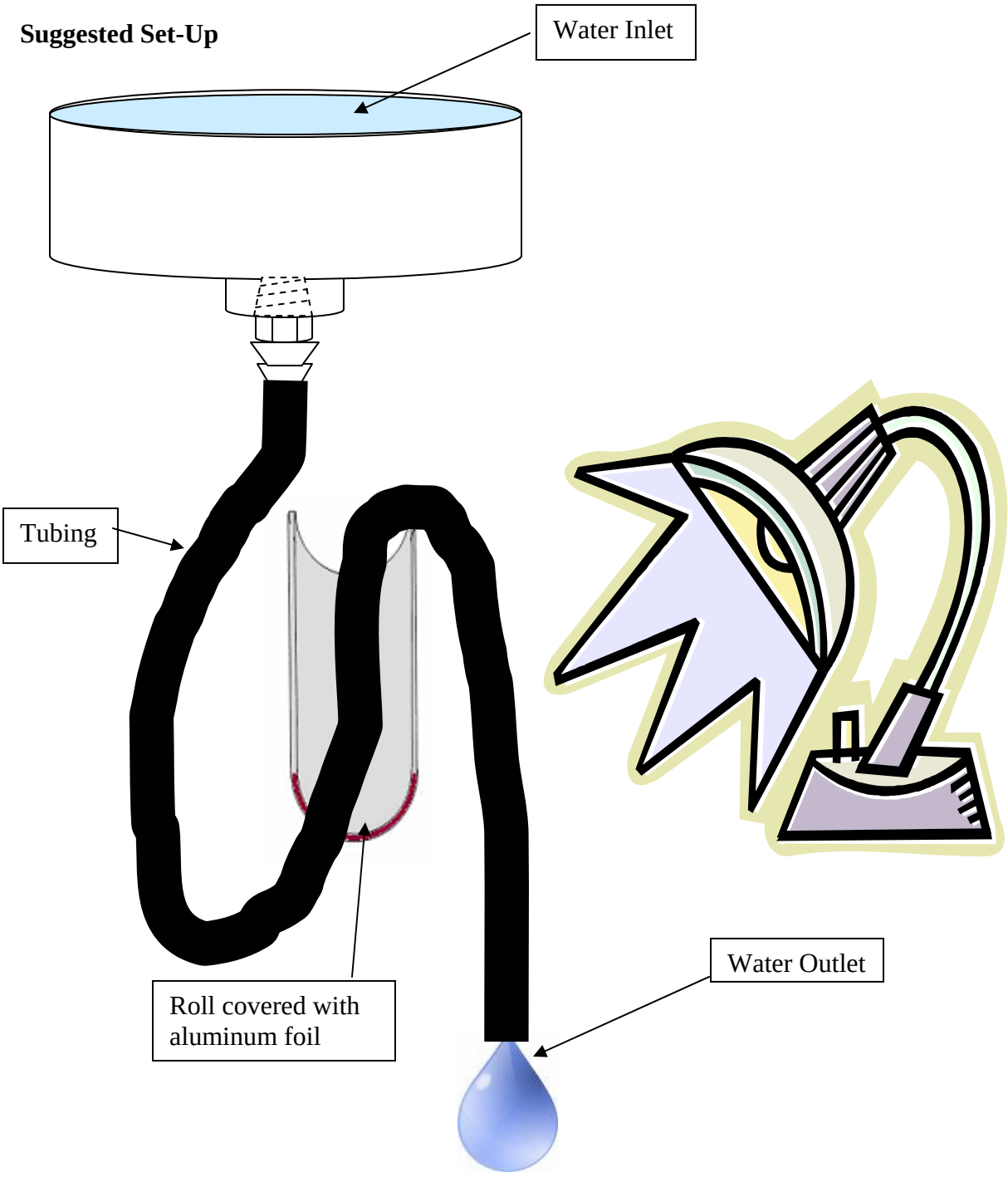
- 4” PVC Cleanout Adapter (approx $3 at Home Depot)

- ¾” x ½” brass male adapter ($1.90 each)

Pre-Activity Preparation

- You will need to drill a hole into the 4” PVC cleanout adapter in order to screw on the brass male adapter. Everything else can be assembled by the students
- Included below is a sketch of what the final set-up should look like. Students can come up with their own design and set-up. Keep in mind also, that a simple cup with the tube held in place by clay can be attempted first. If a water tight seal cannot be created then an improved design will be required. This can be a good engineering lesson, just be prepared to make the trip to a hardware store.

Suggested Set-Up



With the Students

1. Start by asking the students ways they could collect the sun's energy. They are going to collect the energy in the form of heat. Talk about which colors absorb the most heat and how they could 'direct' the rays of the sun onto one point
2. Review with the students the scientific method, in particular what a hypothesis is. Give them examples for various hypotheses in the form of "IF THEN" statements.
3. Go over with the students the handout that goes with this activity. Specifically going over what it means to me an engineer and how they will utilize the scientific method to come up with the best design.
4. Also, go over with the students that their goal will be to develop a solar water heat that will heat the water the most in the allotted amount of time.
5. Have the students complete the handout by filling in the hypotheses and drawing a sketch of their design. (this will probably wrap-up the first 50 min class)
6. Have the students start to put together their designs and verify that their water heaters are water proof and that water can flow from the inlet to the outlet.
7. You can start out by simply trying out a paper or Styrofoam cup with the tubing held in place with clay. See if the students can get a water tight seal. If they cannot, then try the scaled-up version with the PVC and brass adapters.
8. Once all the students are ready, give them all the same amount of water at the same temperature. Starting at the same time, instruct the students to begin. Their goal will be: using the solar water heaters only, which group can cause the greatest increase in water temperature.
9. Make sure the students record the temperature of their water in 2-3 minute intervals.
10. The group that successfully recorded their date and caused the greatest temperature increase will win.
11. Have the group that won explain to the other groups why their design was successful.

Lesson Closure

Investigating Questions

- What did you do to maximize the temperature increase of water?
- How did you maximize the amount of time the water spent directly under the light?
- How did you slow down the flow of water?
- What improvements would you make in your design?

Lesson Extension Activities

Have the students identify what were the independent, dependent, and control variables. Have them graph the temperature of the water vs. time.

References

www.wattsonschools.com

Owner

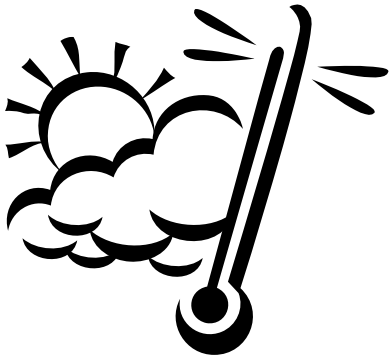
Drexel University GK-12 Program

Contributors

Jason Coleman

Copyright

Student Handout #1



You are design engineers for an environmental engineering firm called Solar Engineering Incorporated. The president of this company is Ms. Amicone and the engineering manager is Mr. Coleman. Due to an increase in the costs of energy used in the home, specifically, the costs to heat water, the government has called upon Solar Engineering Incorporated to come up with an alternative way to heat the water within our homes.

Due to our background and expertise in solar energy, the energy of the sun will be used to heat the water. It is our job as engineers to develop a way to best utilize the suns energy for heating water. The first step will be to develop a model. This model will be used to test various hypotheses about the best ways to use the suns energy. Our model should provide the answers to the following hypotheses:

IF we increase the amount of time the water is exposed to the sun **THEN**

IF we decrease the flow rate of the water **THEN**

IF we paint the tubing black **THEN**

(why??)

IF we remove the aluminum foil from the paper towel rolls **THEN**

IF we increase the height of the first cup **THEN**

IF we lower the starting temperature of the water **THEN**

IF we decrease the inside diameter of the tubing **THEN**

Can you think of any other hypotheses that you would like to test? If so, write them below:

IF _____

THEN _____

IF _____

THEN _____

IF _____

THEN _____

In the space below, draw a picture of your solar water heater and label the parts.

What else might engineers consider when designing a solar water heater?

Student Handout #2

Make improvements to your set-up to increase the temperature change

Describe and/or draw your current set-up and the improvements and changes that you made

Starting Temperature: _____ Ending Temperature: _____ Temperature Change: _____

Make improvements to your set-up to increase the temperature change

Describe and/or draw your current set-up and the improvements and changes that you made

Starting Temperature: _____ Ending Temperature: _____ Temperature Change: _____