Making a Solar Collector

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Topic

Solar energy

Time

2 to 3 hours

Safety

Please click on the safety icon to view the safety precautions. Adult supervision is required. Spray paint outdoors or in a well-ventilated area. Cover all surfaces surrounding the box with newspaper when painting. Be careful when using the knife or scissors.

Materials

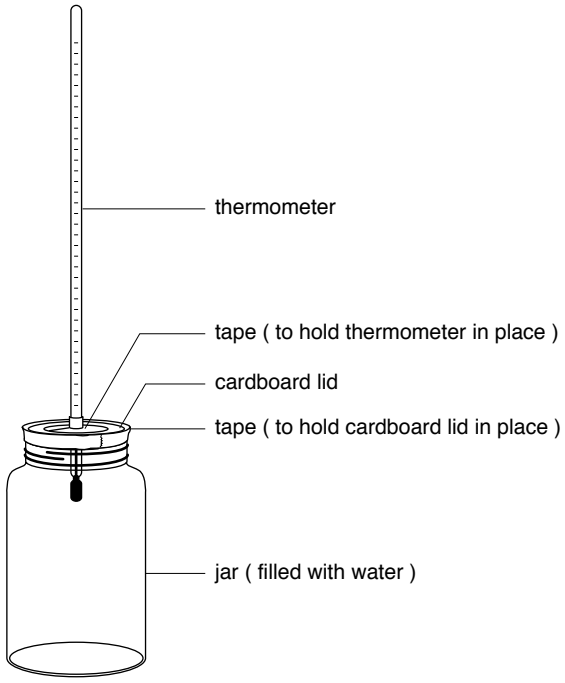
three glass jars (they should all be the same size)
masking tape
three outdoor or standard lab thermometers
aluminum foil
one cardboard tube from a roll of paper towels or two tubes from rolls of toilet paper
black construction paper
stiff cardboard
clear tape
matte knife or scissors
medium-size cardboard box (approximately 60 cm 2 40 cm 2 30 cm)
small electric fan
extension cord
plastic wrap
ruler
can of flat black spray paint
watch or stopwatch

Procedure

Part A

1. Cut out three cardboard tops for the jars.
2. Poke a hole with a pencil, or cut a hole in the center of each cardboard lid through which you can insert a thermometer.
3. Wrap one of the jars with the aluminum foil. Wrap another jar with the black construction paper. Leave the third jar as it is.
4. Fill the three jars with water, and tape the lids in place. Place one thermometer in each of the jars, and tape them in place. Make sure that enough of the thermometer sticks out so that you can read it (see figure 1). Be sure that the thermometers do not touch the bottoms or sides of the jars. Record the starting temperatures in all three jars on data table 1.

Figure 1



5. Place the jars in the sun. Take a temperature reading after 1 min, and every minute for the next 10 min. Enter the readings on data table 1.

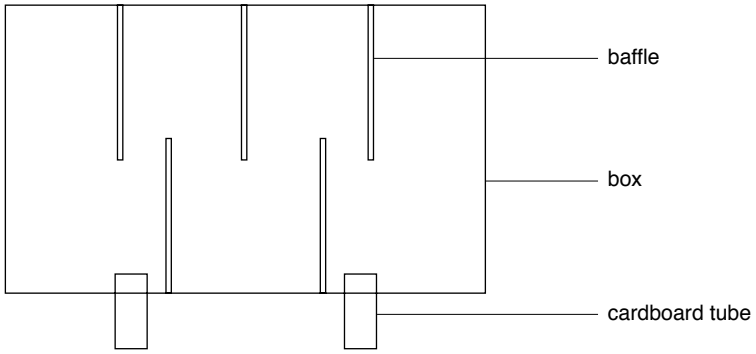
DATA TABLE 1

Time (min)	Temperature (°C)		
	Plain jar	Jar with foil	Jar with black paper
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

PART B

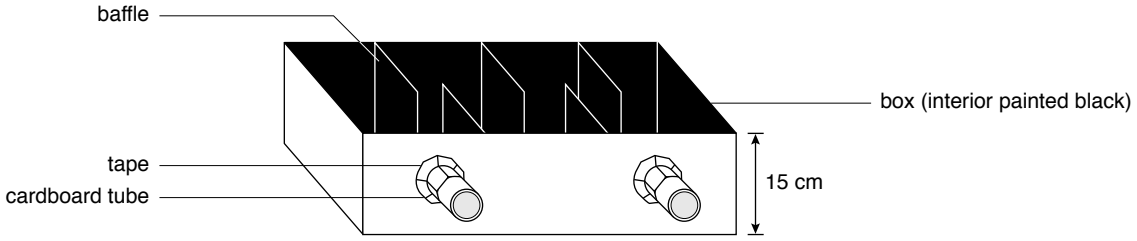
1. Cut the sides off the cardboard box so that it is 15 cm deep. Use the ruler to be accurate. Save the pieces you cut off.
2. Cut the extra cardboard so that you have five pieces 15 2 16 cm. Tape these in place, as shown in figure 2, to create baffles that will deflect the air as it passes through the box.

Figure 2



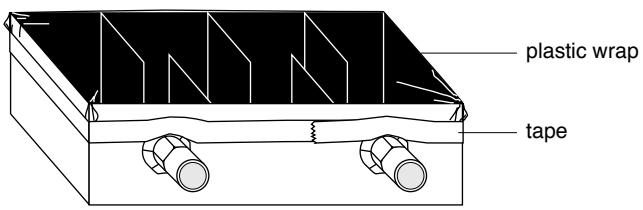
3. Cut two holes in one of the longer sides of the box, as shown in figure 2. Place the cardboard tubes through the holes so that 4 cm of each are inside the box, and tape them in place.
4. Spray the inside of the box with the black paint (see figure 3a). Be sure to cover the area around the box with newspaper so that you don't get paint on it.

Figure 3a



5. Cover the entire open surface of the box with the plastic wrap (see figure 3b). Tape this in place along the edges.

Figure 3b



6. Place the thermometers in direct sunlight for a few minutes. Observe them until the temperature readings stabilize and you have an accurate reading of the outside temperature. Record this on data table 2 under "Starting temp." Record the time under "Starting time."
7. Take the collector outside, and place it in the direct sunlight. Place the thermometers in the tubes so that you can read the scales through the plastic wrap. Tape the thermometers in place.
8. Allow the collector to sit for 5 min.
9. After 5 min, record the time and temperature again. Record the temperature every 5 min until the reading stabilizes.
10. Use the fan to blow air through one of the tubes (you may need to use the extension cord so that the fan can reach the outside). Place your hand near the other tube. Note any difference in temperature that you feel with your hand. Record the temperature in both tubes after 2 min.

DATA TABLE 2

Time (min)	Temperature (°C)	Time (min)	Temperature (°C)	
Starting time	Starting temp.	20		
		25		
5		30		
10		After fan blows for 2 min	Tube 1	Tube 2
15				

11. Which of the jars heated the fastest? Which of the jars heated the slowest? How can you explain the differences in temperature?
12. Why do you think that the inside surface of the collector is painted black?
13. What purpose does the plastic wrap serve?
14. What uses do you think this type of solar collector might serve? How might you make a collector to heat water?

What's Going On

The jar with the black construction paper heated the fastest. This is because the black paper absorbs energy in the form of heat, and in this way heats the water. The aluminum-wrapped jar heated the slowest. This is because the shiny silver surface of the foil reflects sunlight and does not absorb it. When light is absorbed, it is transformed into heat energy, whereas when it is reflected, most if it remains in the form of light. The inside of the collector is painted black so that it will absorb heat from the sun's rays. This in turn heats the air inside the collector to a temperature greater than that outside. The plastic wrap allows the collector to retain heat.

Energy travels in waves (or rays). The plastic wrap allows the light rays to pass through and reach the black surface. Although the black surface reflects very little light back into the air, the heat it radiates would dissipate rapidly if the plastic wrap were not there to retain it. The wavelength of the heat waves cannot pass through

the plastic, so the temperature inside the box rises. This is an example of what is referred to as the *greenhouse effect.* Collectors similar to the one you built could be used to heat air that could then be pumped through a building to heat it. Since water will retain heat longer than air, it is often more practical to heat water with solar energy. By running black-painted pipes through the collector, water running through them could be heated. This heated water could be used as a source of hot water or collected in barrels so that the heat it gave off as it cooled could be used to heat a room or even a whole house.

In this experiment you explored the potential of the sun's energy by building a solar collector, a device to make solar energy available for heating.

Connections

Most of the energy used today to heat and cool buildings, run machines and vehicles, and manufacture goods is provided by the burning of fossil fuels. These fuels, including coal, oil, and natural gas, are actually the remains of ancient plants and animals. Because they took millions of years to form, fossil fuels, are not easily replenished and are quickly being used up. This, coupled with the fact that the burning of these fuels fills the air and water with harmful pollutants, makes it necessary to find alternative fuel sources.

The most directly available and abundant alternative is solar energy, provided by the sun. Scientists and engineers are researching and developing ways of using solar energy for our day-to-day needs. You can utilize the sun for heating your house by installing solar collectors on the roof of your house. They should be placed on the south-facing roof. The angle of your roof is extremely important to the efficiency of the collectors. The roof should be as perpendicular as possible to the winter sun.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES