Insulation: Keeping Heat In or Out

Many parts of the country experience large changes in temperature from season to season. But human comfort demands a fairly constant temperature in homes and work places throughout the year. In cold weather, this means preventing the escape of heat to the outdoors. In hot weather, it means blocking the invasion of heat from the outdoors.

Insulation helps maintain human comfort by blocking heat flow. Some materials are more effective insulators that others. The best insulating material for the home will be one which keeps the most heat in during cold weather and the most heat out during hot weather.

Solar energy collectors also must contain insulation to prevent the collected heat from flowing back into the atmosphere. Hot water tanks and pipes need insulation, too, so that the water they contain doesn't lose its heat.

Objectives

At the completion of this activity, you should be able to

- compare different insulating materials for their abilities to keep heat in and to keep heat out,
- determine the best material for insulating against heat loss and against heat gain,
- explain why insulation is an important part of a solar energy collector, and
- explain the importance of insulating homes to reduce heat loss from the inside in cold weather and heat gain from the outside in hot weather.

Skills and Knowledge You Need

Reading a thermometer
Recording and graphing data

Materials

three identical soda cans
three Celsius thermometers
a clock, watch, or timer to measure minutes
a 200-watt incandescent lamp or flood lamp (with reflector and mounted on a ringstand)
hot water (50 C)
insulating materials:
- fiberglass
- wool
- styrofoam
- newspaper
- aluminum foil

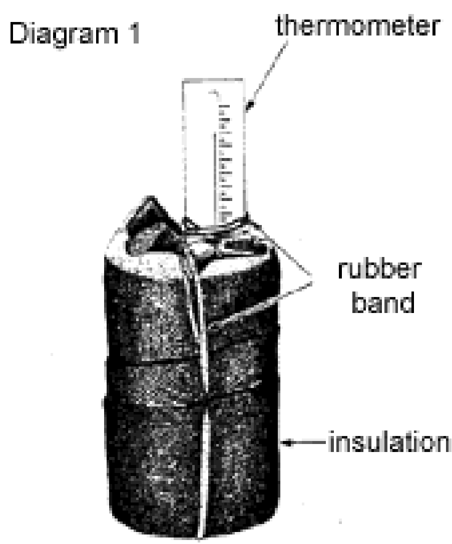
rubber bands
metric ruler
safety glasses

Procedure

Part 1: Keeping Heat In

1. Fill the three soda cans to within 1 cm of the top with the hot water.

2. Obtain two of the insulating materials. Carefully and completely wrap one can with one insulation and a second can with the other. Make sure you wrap the can tops, but leave a small hole above the pop-top opening for the thermometer. (See Diagram 1) Hold the insulation in place with rubber bands.



Caution: Do not spill any water on the insulation when wrapping the cans. If you choose fiberglass as the insulation, wear safety glasses and gloves when handling it.

3. Leave the third can unwrapped.

4. Wrap rubber bands around the tops of the three thermometers. Insert the thermometers through the insulation and pop-top opening into the cans. Adjust the rubber bands so that the thermometers are at equal depths (about halfway) in the cans and do not touch any part of the cans.

5. Label the first two columns of Data Table 1 with the kinds of insulation you are using.

6. Read and record in Data Table 1 the temperature of the water in each can.

7. Continue to record the water temperature in each can every minute for 20 minutes.

8. On Graph 1, plot your data for each can. Be sure to label each line.

Part 2: Keeping Heat Out

9. Remove the thermometers and insulation and empty the cans.

10. Replace the same insulation and the thermometers. Position them just as you did in Part 1.

11. Place each can the same distance (about 30 cm) from the heat source (the lamp), as shown in Diagram 2.

12. Label the first two columns of Data Table 2 in the same way as you labeled Data Table 1.

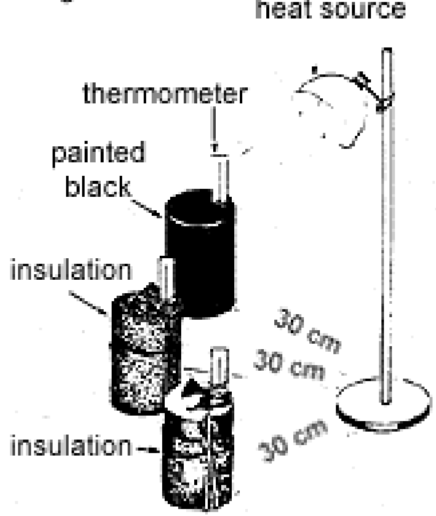
13. Read and record in Data Table 2 the temperature of each can.

14. Turn on the heat source. Record the temperature in each can every minute for 15 minutes.

    Caution: Do not look directly at the lamp. Read the thermometers from behind the lamp.

15. Turn off the heat source. On Graph 2, plot your data for each can. Be sure to label each line.

Diagram 2



Questions

1. What general conclusions can you draw from the graphs?

2. What was the total change in temperature for each can in Part 1? In Part 2?

3. Why did you use the third can in this activity?

4. Of the materials you tested, which was better at keeping heat in? How do you know?

5. Which material was better at keeping heat out? How do you know?

6. Was the same material the better insulator in both cases?

7. Compare your results with those obtained by the rest of the class. Which material would best insulate against heat loss (keep the heat in)?

8. Which material would best insulate against heat gain (keep the heat out)?

9. Based on your results, why do you think insulation is an important part of a solar energy collector?

10. Why should a house be insulated to reduce both heat loss and heat gain?

Looking Back

A good insulation reduced heat flow from warm areas to cold areas. In this activity you simulated cold weather conditions by insulating cans filled with hot water to try to keep the heat in. You also simulated hot weather conditions by insulating empty cans to try to keep the heat out.

The best insulation are the ones that allowed the smallest temperature change inside the insulated can. In choosing an insulation for a house or a solar collector, you would also consider other factors such as cost and safety.

Insulation makes an important contribution to saving energy and maintaining human comfort.

Going Further

Repeat the activity using other sources of heat energy, including the sun. Compare these results to your original results and explain any differences.

Find out the R-values of the insulation you tested. Write a paragraph explaining R-values, and then compare your results in this activity to the R-values of the insulation you tested. Do they agree? Why or why not? Refer to transparency A24.

Visit a lumber yard and insulation contractor to find out as much as you can about insulation. Gather information on R-values and costs, then recommend an insulation based on these factors.

Find out the kind, amount, and location of insulation in your home. Determine its R-value. Find out the recommended R-values for walls, ceilings, floors, and basements in your area of the country. If you find your home is not adequately insulated, develop a list of recommendations for improving its insulation. Refer to transparency A25.

Research how homes are kept cool in summer. List as many ways to prevent heat gain as you can.

Hold a “cool cube” contest. Design a container that will keep an ice cube from melting for the longest time. Which container wins? Why? (The best containers may hold ice for as long as 15 hours!)

Data Table 1
Keeping Heat In

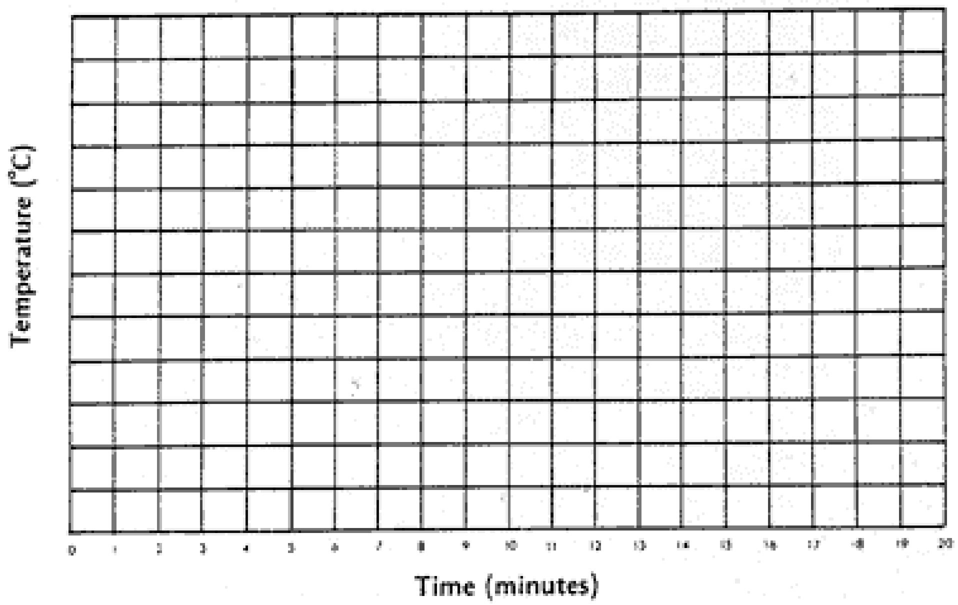
	Temperature (°C)		
Time (minutes)	First Can Temperature (Insulating Material: ________________)	Second Can Temperature (Insulating Material: ________________)	Third Can (No Insulating Material)
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Data Table 2
Keeping Heat Out

	Temperature (°C)		
Time (minutes)	First Can Temperature (Insulating Material: ________________)	Second Can Temperature (Insulating Material: ________________)	Third Can (No Insulating Material)
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

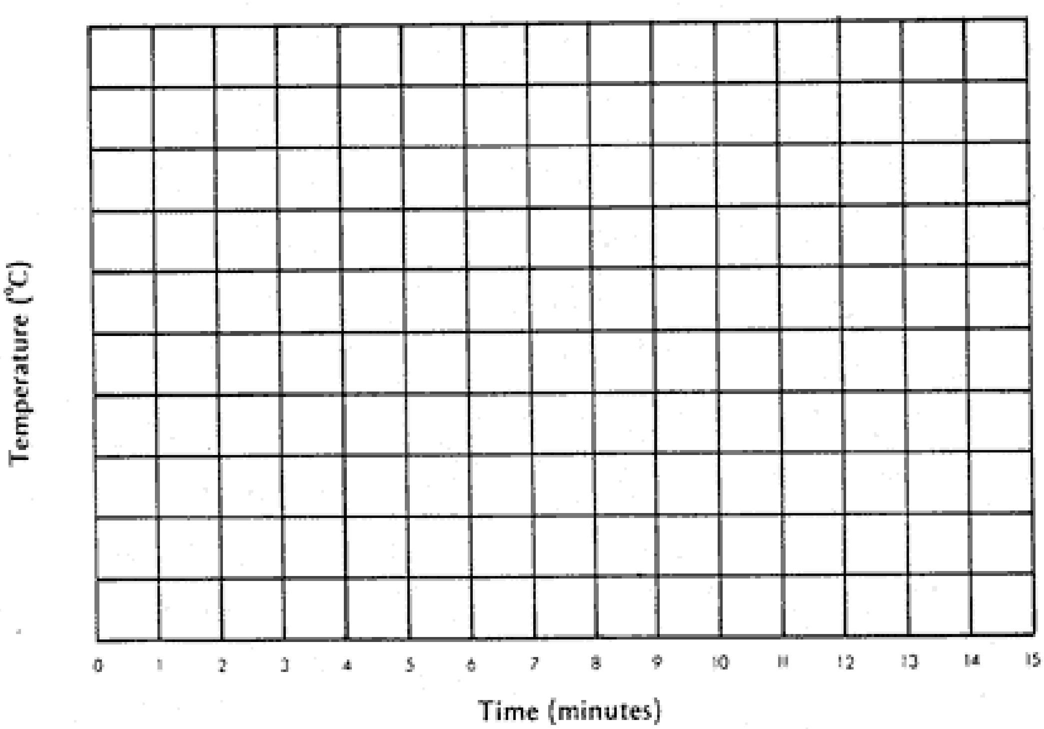
Graph 1

Keeping Heat In



Graph 2

Keeping Heat Out



Teacher Information

Insulation: Keeping Heat In or Out

Suggested Grade Level and Discipline:
Science, grades 6-9
Physical Science
Technology

Skill Objectives:
Recording temperature data at equal time intervals

Graphing data and interpreting heating and cooling curves

Drawing inferences from graphed data

Applying results to everyday situations

Major Understandings

The best insulation against heat loss is that which allows the smallest change in the interior temperature of a container when the container is exposed to a cooler external environment.

The best insulation against heat gain is that which allows the smallest change in the interior temperature of a container when the container is exposed to a constant source of heat energy.

Some materials are good insulators against both heat gain and heat loss and thus are good insulation materials in home construction.

Because of the diffuse nature of solar energy, insulation is needed in a solar collector to trap and concentrate heat energy.

Adequate home insulation for keeping heat in during cold weather and heat out during hot weather is an important factor in conserving energy and decreasing fuel costs.

Background

Insulation is any material used to slow heat transfer. The important component of most good insulators is stationary air because air is a poor conductor of heat. Most insulation contains millions of tiny air spaces which slow heat conduction through it. Thus the heat is "kept in" or "kept out," as this activity demonstrates.

Insulation is rated for its resistance to heat flow. This resistance is known as the insulation's R-value. The greater an insulation's R-value, the greater is its resistance. Some sample R-values are listed in the table.

Home insulation is intended to serve two purposes. In winter the insulation should keep heat in, while in summer it should keep heat out. Virtually all insulations slow heat transfer through the material in both directions since this is just a result of poor heat conduction through those tiny air spaces. However, foils are often added to commercial insulations to gain an additional energy-saving factor: the reflection of heat energy, either back into the living spaces in winter, or back to the outside in summer.

Table A24
Typical R-Values of Different Forms of Insulation

	R/inch	Inches Needed For					
		R11	R19	R22	R34	R38	R49
Loose Fill							
Fiberglass	2.25	5	8.5	10	15.5	17	22
Mineral Wool	3.125	3.5	6	7	11	12.5	16
Cellulose	3.7	3	5.5	6	9.5	10.5	13.5
Vermiculite	2.1	5.5	9	10.5	16.5	18	23.5
Batts or Blankets							
Fiberglass	3.14	3.5	6	7	11	12.5	16
Mineral Wool	3.14	3.5	6	7	11	12.5	16
Rigid Board							
Polystyrene beadboard (expanded)	3.6	3	5.5	6.5	9.5	10.5	14
Extruded polystyrene	4-5.41	3-2	5-3.5	5.5-4	8.5-6.5	9.5-7	12.5-9
Urethane	6.2	2	3	3.5	5.5	6.5	8
Fiberglass	4.0	3	5	5.5	8.5	9.5	12.5

Adequate insulation of homes and buildings is an important factor in energy conservation and reduced energy costs. According to a recent American Institute of Architects study, by 1990 we could save one-third of our current total U.S. energy use through improved design of new buildings and retro-fitting of old ones. A good portion of this saving would come from improved insulation. And just think of the savings in dollars.

Insulation is an extremely important factor in a solar collector, too. Without insulation to trap the heat collected, a solar collector could never attain the temperatures necessary to provide domestic hot water or space heating.

Advance Planning

Begin collecting soda cans and insulations several weeks ahead. Students can help by bringing cans and scrap insulation from home. Home centers, lumber yards, or insulation contractors may provide you with insulation contractors may provide you with insulation samples or scrap. The home economics teacher may be able to provide wool scraps.

Attach the lamps to the ringstands so that the light will strike the cans on the tops and sides. Be careful to keep the lamps from shining directly in students' eyes. The best set-up is to place the lamps low to the table so that students stand above them.

Make preparations to provide 50 C water. Often a hot plate and an old coffee pot works best.

You may want to cut scrap insulations to size before the activity. Students can help with this task outside of class time.

Suggested Time Allotment

Two class periods to set up and perform the activity
One class period to graph data and compare and discuss results

Suggested Approach

Students can work in groups of three. One can be the timer, and the other two can read and record the temperatures.

After the students have collected and interpreted their data, discuss the importance of insulation in home energy conservation and in solar collectors.

If necessary, give students help with graphing, labeling lines, and drawing general conclusions from the graphs.

If there are not enough lamps for several small groups of students, perform this activity in conjunction with other solar activities. Rotate groups from activity to activity over the course of several days.

Precautions

Students should not look directly at the lamps. Remind them to stand behind the lamps as they collect data.

Students should wear safety glasses and gloves when handling fiberglass insulation.

If the water is hotter than 50 C, consider pouring it into the cans yourself. Provide students with mitts or gloves to handle hot glassware and cans.

Do not use shiny cans as the control cans. In Part 2 they will reflect too much heat. You should spray all the cans with flat black paint, including the control set-up can.

Points for Discussion

How rapidly did the control can lose heat in comparison to your insulated cans? Gain heat? Why?

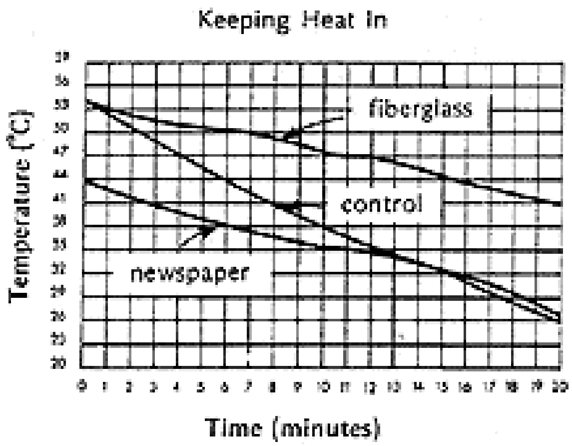
Which insulation slowed heat flow the least? The most? Of the materials tested by your class, which would you recommend as the best home insulation? Why?

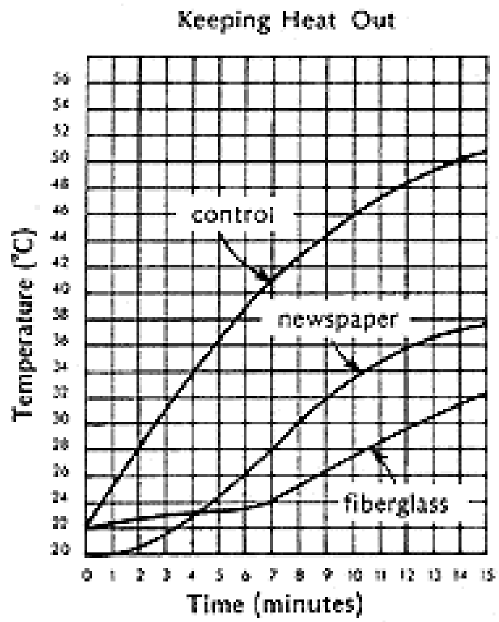
How might you use insulation in active and passive solar heating and cooling?

By what processes does heat flow from one object to another or to the surrounding air?

Typical Results

The following graphs represent sample results obtained using newspaper and fiberglass as insulations.





Evaluation

Inspect students' data tables and graphs for accuracy, clarity, and attention to detail.

Review students' answers to the questions to determine if they have made supportable inferences from the data collected.

Ask students to explain why insulation is important in a solar collector.

Request students to discuss in writing one application of their findings too home energy conservation. Inspect their work to see if the suggestion is logical and conforms with the data from this activity.

The two graphs on this page indicate that newspaper excels compared to the control at "Keeping Heat In" and "Keeping Heat Out" even when the set-up having newspaper insulation begins at a lower temperature.

Modifications

Although this activity is designed to use low-cost metal-backed thermometers, short laboratory thermometers can be substituted.

This activity could also be performed using the sun as a source of energy.

References

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