Air Space

Teacher

Introduction

Heating and cooling costs are one of many problems facing South Dakotans. The harsh South Dakota winters and scorching summers always have been problematic for South Dakotans. Especially now, when fuel costs are reaching all time highs, comfort is giving way to thermostat adjustments. Wars, hurricanes, increased human demand, and damaged pipelines are just a few of the obstacles fueling the energy crisis. Billions of dollars are being invested into alternative fuels and technological advancements to help eliminate the energy crisis in the future. Government incentives like low interest loans or grants to help defer the cost of re-insulating older homes would be an immediate fix to alleviate a portion of the energy demand.

According to the 2nd Law of Thermodynamics, heat will naturally transfer from a warmer body to a colder body. For example: heat will transfer from the inside of a warm house in the winter to the outside. Insulation is designed to prevent the flow of heat though the walls of a house. Insulation has an R-value, which indicates its ability to reduce the amount of heat that passes through it. A higher R-value means more resistance so less heat will pass through. Newer building codes suggest an R-value of 22 in the walls, 11 in the basement and an R value of 44 in the ceiling/roof. Note: These values will vary depending on your regional and local building codes.

In older homes the insulation was applied loose between the studs. The insulation and the air trapped in the insulation prevented heat from transferring though the walls. Over time, the insulation in older homes has settled to the bottom of the walls. The settling has left large gaps of un-insulated air in most of the wall. The open air space does not insulate very well.

In today's lab, you will test whether a properly insulated home will reduce the amount of heat that is transferred through the walls. Simple materials like cardboard boxes and shredded paper will be used to complete the experiment.

Materials (listed per lab group)

3 – 5″x5″x5″ cardboard boxes (small boxes – all should be same size)
3 – 7″x7″x7″ cardboard boxes (small boxes – all should be same size)
http://www.uline.com/BoxListing1.asp - box vender (the suggested sizes can vary as long as all of the small boxes are the same size and all of the larger boxes are the same size.)
1 – Bag of shredded paper or packing peanuts
1 – Stopwatch or clock with second/minute hands
1 – Access to an electric balance
1 – Metric ruler (mark 1/4 line on box)
1 – Marker (mark 1/4 line on box)
3 – Indoor/outdoor thermometer (insert probe into the box before it is placed in the freezer)
1 – Role of masking tape
1 – Graph paper or access to a computer with graphing program
1 – Data book to record results
1 – Freezer (could be completed outdoors in the winter) hint: some indoor/outdoor thermometer readouts must be operated at room temp. You may choose to extend the wire of the probe through a window. The kids could monitor the thermometer readouts inside while the boxes are located outside in the cold.

Process:

A cardboard box (7″x7″x7″) will represent a one room house with 4 exterior walls, a floor and a ceiling. A smaller box (5″x5″x5″) will be placed in the larger box to represent the interior wall; the space between the boxes represents the space between the interior wall and the exterior of the house.

No insulation will be placed in the space for the 1st setup. The second setup will have insulation on the bottom about 1/4 of the way up the side walls. This will represent an older home with settled insulation. The last setup will be completely insulated. This will be our control because we naturally assume a home should be insulated.

The probe of an indoor/outdoor thermometer will be placed in each of the smaller boxes. The boxes are then placed in a freezer. An initial temperature reading is taken and temperature readings are taken every 2 minutes for 20 minutes and recorded on the data chart.

Data Table #1 Results will vary

Time (2min)	Non-Insulated 0 – Grams	1/4 Insulated ______ Grams	Insulated ______ Grams
Initial			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Setup:

1. Obtain the materials listed above.
2. Assemble the following:
   A. Non-insulated home
   1. Suspend an indoor/outdoor thermometer bulb from the inside of the small box using tape. (Care should be taken so the thermometer bulb is not touched during the assembly.)
   2. Close the small box – secure with tape
   3. Place the small box inside the larger box
   4. Close the larger box – secure with tape
   5. Label the box and place to the side (empty box).

   B. Older home (1/4 insulation)
   1. Suspend an indoor/outdoor thermometer bulb from the inside of the small box using tape. (Care should be taken so the thermometer bulb is not touched during the assembly.)
   2. Close the small box – secure with tape
   3. Use a ruler and marker to indicated the 1/4 mark on the side of the large box. The mark should be made on inside and outside of the box. This will be the height of the insulation. The mark should be made 4.5 cm from the bottom of the box.
   4. Use a balance to measure 35 grams of shredded paper.
   5. Place approximately 2 cm of shredded paper on the bottom of the large box. Place the small box inside the larger box. Insert the remaining insulation around the smaller box. Fill and compress to the 1/4 line.
   6. Close the larger box – secure with tape
   7. Label the box and place to the side (Older home - 1/4 insulation).

   C. Insulated home (control)
   1. Suspend an indoor/outdoor thermometer bulb from the inside of the small box using tape. (Care should be taken so the thermometer bulb is not touched during the assembly.)
   2. Close the small box – secure with tape
   3. Use a balance to measure 135 grams of shredded paper.
   4. Place approximately 2.5 cm of shredded paper on the bottom of the large box. Place the small box inside the larger box. Insert the remaining insulation around and on top of the smaller box.
   5. Close the larger box – secure with tape
   6. Label the box (Insulated home).
3. Place the boxes in the freezer. The thermometer readouts should be placed on the top of the freezer. The freezer should not be opened until all of the measurements have been taken.
4. An initial temperature reading is taken and temperature readings are taken every 2 minutes for 20 minutes and recorded. (Data Table #1)
5. Clean your testing area in accordance to your teacher's discretion.
6. Graph the results using an X-Y graph. Time is the independent variable. The independent variable is independent of change and is not affected by the experiment. The independent variable is usually placed on the X-axis. The temperature change is the dependent variable because it changes with time and it is affected by the amount of insulation added to each box. The dependent variable is usually placed on the Y-axis.

Air Space Teacher Handout

Data analysis (Questions)

1. Why must care be taken not to touch the thermometer bulb during the initial setup? Heat will be transferred very quickly from the skin to the sensitive thermometer bulb. The increase in temperature will affect the final result making comparisons inaccurate.

2. Why should the freezer remain closed during the investigation? Heat will enter the freezer raising the inside temperature. The temperature change within the boxes will be reduced resulting in conflicting results with other lab groups.

3. What does R-value mean? According to the 2nd Law of Thermodynamics, heat will naturally transfer from a warmer body to a colder body. Insulation is designed to prevent the flow of heat though the walls of a house. Insulation has an R-value which indicates its ability to reduce the amount of heat that passes through it. A higher R-value means more resistance so less heat will pass through. Newer building codes suggest an R-value of 22 in the walls, 11 in the basement and an R value of 44 in the ceiling/roof.

4. What was the decrease in temperature for each of the following?
   a. Loss = (Initial Temp – Final Temp) – results will vary
      1. Non-insulated _________ (°F)
      2. 1/4 insulated ___________ (°F)
      3. Insulated ____________ (°F)
   b. Are your results exactly the same as other lab groups? No they are not

   c. Can you provide an explanation for your results? The students should see the greatest loss in the non-insulated box, then the 1/4 insulated and finally the insulated. The degree of change will vary depending on variables like the following: initial temperature of the freezer, the size of the boxes used, the type and amount of insulation used, the insulation compaction, etc.

   d. Normally the Celsius scale is used in scientific experiments. Why was the Fahrenheit scale used in this experiment? The students need to realize that the Celsius scale should be used in the laboratory setting. Although, in this application the students will be more familiar and comfortable with the Fahrenheit scale because it is used every day in relationship to weather. It would be more relative for a student to hear 70 degrees Fahrenheit instead of 21 degrees Celsius. Extension: you could have the students convert the temperature readings to degrees Celsius.

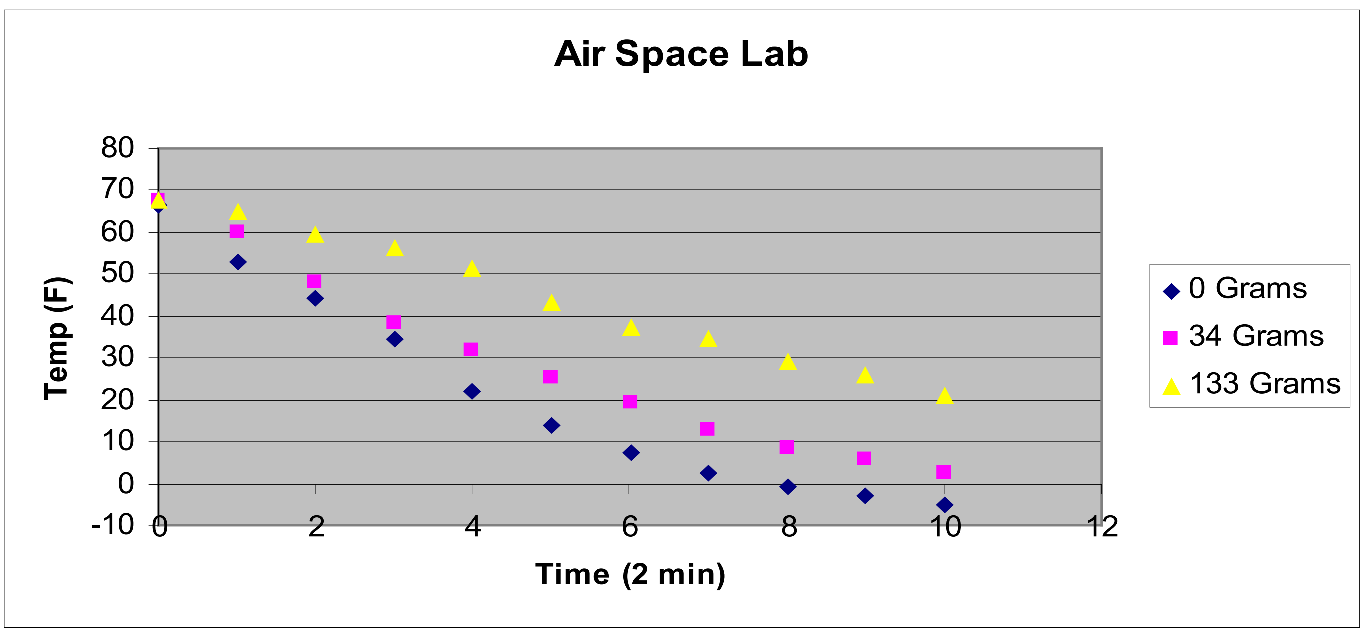
5. Would re-insulating an older home be an effective method to reduce the amount of energy needed to heat a home? Re-insulating a home that is un-insulated or partially insulated will reduce the amount of energy needed to heat it. The cost of re-insulating a home would eventually be recovered by the monthly energy savings. The duration of time needed to recover the investment will vary. The size of the home, the amount of original insulation, the current cost of materials and fuel would be a few of the variables that must be considered.

In the house – extension questions – Answers will vary

1. What is the average monthly bill paid to heat your home? $ ____ _______
2. a. In what year was your home built? ______ b. Square footage ____
3. Compare your answers with other members of your class. ____
4. Do you feel re-insulating is a suggested option for your home to help reduce the cost needed to heat it? ____________

Example X-Y scatter graph using Excel.

	Temperature Degrees Fahrenheit		
	Non-Insulated	1/4 Insulated	Completed Insulated
Time (2min)	0 grams	34 grams	133 grams
0	66.7	67.6	67.3
1	52.9	59.9	64.7
2	44.1	48	59.4
3	34.2	38.1	56.1
4	22.1	31.8	51.3
5	14	25.2	43.2
6	7.1	19.5	37.3
7	2.6	13	34.2
8	-0.7	8.3	29.1
9	-3.2	5.8	25.6
10	-5.3	2.3	20.7



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