CHALLENGES IN PHYSICAL SCIENCE®

Solar House

A Supplemental Curriculum for Middle School Physical Science

From Project DESIGNS: Doable Engineering Science Investigations Geared for Non-science Students

Edited by
Harold P. Coyle
John L. Hines
Kerry J. Rasmussen
Philip M. Sadler

Illustrations by
Kerry J. Rasmussen

NATIONAL SCIENCE FOUNDATION

Sponsored by the
Harvard-Smithsonian Center for Astrophysics
with funding from the
National Science Foundation and
additional support from the
Smithsonian Institution

KENDALL/HUNT PUBLISHING COMPANY
4050 Westmark Drive Dubuque, Iowa 52002

Project DESIGNS

Project Staff

Philip M. Sadler, *Principal Investigator*
Harold P. Coyle, *Project Manager & Publications Manager*
John L. Hines, *Laboratory Technician & Quality Control*
Marcus G. Lieberman, *Education Evaluator*
Annette Trenga, *Assistant Evaluator*
Marc Schwartz, *Graduate Research Assistant*
Steve Saxenian, *Graduate Research Assistant*
Susan H. Roudebush, *Administrative Support*
Martha A. Lynes, *Master Teacher*
Judith Peritz, *Program Coordinator*
Kerry J. Rasmussen, *Writer / Editor / Illustrations / Research*
Pamela K. R. Sears, *Writer / Editor / Research*

External Auditor

Stephen A. Barbato, *Vice President, Educational Research & Development, Applied Educational Systems, Inc., Lancaster, PA*

Curriculum Development Team

(school affiliation at time of pilot trials)
Stephen Adams, *Lopez Island Middle School, Lopez, WA*
Marilynn Benim, *Arendall Parrott Academy, Kinston, NC*
Anne D. Brown, *Lincoln Middle School, Portland, ME*
Nancy C. Cianchetta, *Parlin Junior High School, Everett, MA*
Matthew Coleman, *Whitford Middle School, Beaverton, OR*
Cynthia D. Crockett, *Contoocook Valley High School, Peterborough, NH*
Kimberly Hoffman, *Doherty Memorial High School, Worcester, MA*
Teresa Jimarez, *Coronado High School, El Paso, TX*
Paul D. Jones, *Montezuma High School, Montezuma, IA*
David E. Jurewicz, *Ephraim Curtis Middle School, Sudbury, MA*
James F. Kaiser, *Sharon Middle School, Sharon, MA*
Milton Kop, *Maryknoll High School, Honolulu, HI*
Barbara Lee, *Hualalai Academy, Kailua-Kona, HI*
James MacNeil, *Concord Middle School (Sanborn), Concord, MA*
Linda Maston McMurry, *E. M. Pease Middle School, San Antonio, TX*
Daniel Monahan, *Cambridge Public Schools, Cambridge, MA*
Sarah Napier, *Fayerweather Street School, Cambridge, MA*
Mary Ann Picard-Guerin, *Cumberland Middle School, Cumberland, RI*
Douglas Prime, *Lancaster Middle School, Lancaster, MA*
Diana Stiefbold, *Heights Elementary School, Sharon, MA*
Mary Trabulsi, *Algonquin Regional High School, Northborough, MA*

Consultants

Jeff Forthofer, *Electrical Engineer*
Jo Harmon, *Education Specialist*
Kim L. Kreiton, *Civil Engineer*
Eric J. Rasmussen, *Architectural Designer*

Cover credits:
Batteries/Electromagnets/Gravity Wheel images © President and Fellows of Harvard College.
Bridges/Windmill/Solar House/Blueprint images © 2000 PhotoDisc, Inc.

ISBN 0-7872-6461-X

This material is based upon work supported by the National Science Foundation under Grant No. ESI-9452767. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

Table of Contents

To the Student v

History of Heating and Cooling Homes 1

Pretest 5

Part I Challenges 9

Challenge 1: Cool House 11
Challenge 1: Preliminary Data Sheet 13
Challenge 1: Design Sheet 15
Challenge 1: Data Sheet 17
Challenge 1: Summary Sheet 19
Challenge 2: Constant Temperature House 23
Challenge 2: Design Sheet 25
Challenge 2: Data Sheet 27
Challenge 2: Summary Sheet 29
Challenge 3: Constantly Cool House 31
Challenge 3: Design Sheet 33
Challenge 3: Data Sheet 35
Challenge 3: Summary Sheet 37

Part II Worksheets 41

Vocabulary 43
The History of Heating and Cooling Homes 47
Conduction, Convection, Insulation 51

Part III Assessment 53

Posttest 55
Assessment 59
Content/Concept Questions 63
Self Assessment 65
Open-Ended Questions 67

To the Student

The challenges in this manual are intended to help you learn about certain topics in physical science. We are especially interested in giving you the chance to study how some devices work that you see or use every day. We also believe that you learn science better by building things, making measurements and observations than by memorizing "facts." Understanding science also requires understanding concepts, which are mostly much harder to learn than facts.

You usually encounter science in the form of technology. You will learn in these challenges that science is how we try to understand the world around us. Technology is about how we use that understanding to solve problems. Every human-made object you see got its start inside someone's brain. Most devices—even something as simple as your pencil—us many ideas from many people. We hope that by working with the challenges in this manual, you will learn something about the science behind the devices. We also hope you will get some idea about how decisions are made to build something: Look at your pencil. It contains ideas developed over the last 300 years by many people around the world. Yet no matter which company made your pencil, there are people right now trying to figure out how to make it better. (Sometimes "better" means just as good but less costly.) Each challenge in the manual is a much simpler example of how we use science and technology to solve problems.

Given the many topics that fit under the heading of physical science, you may wonder why we chose to cover the ones in this manual. Three major concerns determined which topics were covered: 1) What are the most common topics in existing physical science courses? 2) Which science concepts can be linked to those topics? 3) What kinds of simple devices that use these concepts can be built easily and inexpensively? Even as we developed the challenges, our choice of topics changed. Some great ideas that we thought would work, did not. Other ideas turned out to be too complicated or too expensive to use. The challenges in this manual are the result of three years' work by the staff and teachers of Project DESIGNS. We hope you enjoy them as much as we did!

Harold P. Coyle
Cambridge, Massachusetts
Spring 2000

History of Heating and Cooling Homes

Humans can only survive unprotected within a small range of temperatures. We live throughout the world, however, in many different climates. In desert regions on all of the continents the temperature can reach as high as 136°F (58°C). In Antarctica temperatures can reach as low as –129°F (–54°C). How do people survive in these extreme areas?

Throughout history, people have learned the use of insulating and cooling techniques. Animal skins used as clothing provided protection from colder temperatures by keeping a person's body heat from escaping. Animal skins were also used on shelters such as huts or tents to keep heat inside. In warm areas, shelters were created to allow cooling air to flow through them while providing escape from the hot Sun. Let's look at some of these shelters.

Keeping People Warm

The beehive house was used four thousand years ago by people living in areas of Scotland and Ireland. This kind of house is made of blocks of stone stacked on top of each other to form an oddly shaped dome. This type of structure was small and its thick walls retained heat well.

The yurt may be as old as the beehive house. It was used by people living in Central Asia. These people were nomads; they traveled from place to place in order to find new sources of food for themselves and their livestock. Some people still follow these traditions today. The yurts in which they live are a form of tent that is covered with animal skins or brightly colored woven rugs. These coverings insulate the interior of the yurt from the cold air outside.

In eastern regions of North America some groups of people lived in longhouses. These structures were made of wood and were between 40 (12 m) and 330 (100 m) feet long, but never wider than 25 feet (8 m). [1] The long structure was only one story tall and was divided into many small stalls along the sides. Each family lived in a stall and shared fires that were built in a row down the center of the longhouse. The high walls of the stalls broke up any breezes that might have traveled through the long, narrow building and retained the heat inside. The people living in these structures were known as the Iroquois.

In the northern regions of North America and Greenland, people known as the Inuit constructed shelters made from snow and ice. These shelters are known as igloos and are still used today. Mainly temporary, they are designed to keep people warm while they are on fishing and hunting expeditions in the Arctic. Igloos are made by stacking blocks of very firmly packed snow in a spiral pattern to form a dome. The thickness of the blocks insulates the interior of the igloo, retaining any heat inside. The Inuit also learned how to create insulating windows without losing a great deal of heat by placing a clear piece of ice in a hole between the blocks of snow. The Inuit keep icy drafts from blowing into the igloo by hanging a piece of sealskin over the passageway to the door.

In the southwestern United States, some people, referred to today as Pueblo, lived in cliff dwellings. These multistory houses were built into caves and under rock overhangs on cliffsides. The Pueblo people lived in these dwellings between 700 and 1,000 years ago. These dwellings were made primarily of stone and often faced south or southwest so that they could absorb the most heat from the Sun.

Keeping People Cool

In the ancient Middle East and in ancient Greece, a structure known as a megaron was designed. This structure consisted of an open porch, a small entrance hall, and a main hall where a fire could be built. The

[1] *Encyclopedia Britannica.*

open porch allowed breezes to flow through it, while also providing shade from the hot Sun. The main hall served as the living space and allowed air to circulate, cooling its inhabitants.

Many Mediterranean cultures learned a simple way to reflect the Sun's rays: whitewashing. Whitewash is a mixture of lime (which comes from limestone) and water. The mixture is painted on the sides of the buildings to form a white surface that is highly reflective. The whitewash keeps most of the Sun's heat from reaching the inside the buildings. The dwellings stay cool within while the hot Sun glares outside.

Cultures in southeast Asia also learned how to keep their shelters cool. The walls of their dwellings do not reach the roof. The gap between the wall and the roof, known as a clerestory, allows rising hot air to escape. The rising and escaping motion creates a convection current in the air that constantly cools the interior.

Houses of Today

In modern times, air conditioners, fans, and elaborate heating and cooling systems, often called climate control systems, govern the temperatures of our buildings. Climate control systems use electricity or fuel to heat or cool the air, then to circulate the air around the building. Many buildings today do not even have windows that open!

People are now thinking about ways to combine the heating and cooling methods of the past with modern methods to find less expensive solutions to the problem of keeping shelters at a comfortable temperature. Houses designed and built today often use many old methods of keeping warm or cool air inside. Insulation is often used for both purposes. Air flow patterns are created that circulate either warm or cold air to the areas where people live. Houses are even placed at the proper angles so that they collect the most sunlight or avoid it. The structures that use the old methods of heating and cooling are referred to by architects as "sustainable designs."

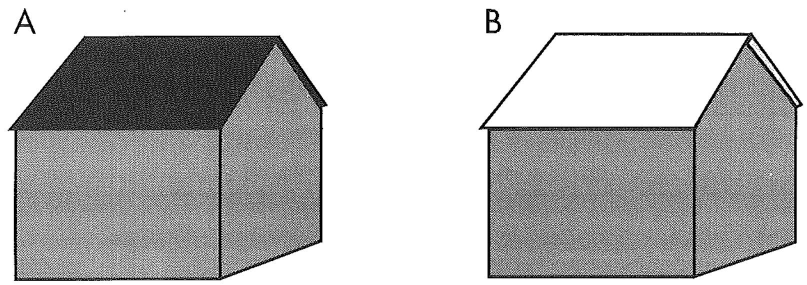
In the future, as we explore areas beyond our own planet, we need to think about how heating and cooling processes work in areas with very little or no atmosphere. Astronauts are comfortable inside their spacecraft, but outside temperatures can soar to hundreds of degrees or plummet well below freezing. Insulation, reflection, and air flow are very important considerations when designing structures for use in space, or perhaps someday, on other planets.

Pretest

NAME: **DATE:**

Answer the following questions in complete sentences.

1. Which house will be hotter under the bright Sun?



2. Two cars are parked in a sunny parking lot. One is painted dark blue. The other is white. Which will remain cooler?

3. Two cars are parked in a sunny parking lot. One is painted dark blue and has open windows. The other is also painted dark blue and has closed windows. Which will remain cooler?

4. On a bright, sunny day, why is it cooler in the forest than in an open field?

5. It is winter in northern Canada. Jana is wearing a heavy wool coat. Kristi is wearing a light cotton shirt. Who will be warmer? Can you explain why?

6. It is a summer day in New York City. Jason goes home to a hot apartment. The windows in his apartment open on the top and the bottom. Jason opens just the top part. Then he puts an electric fan on the floor and turns it on. Why does he do this? Will opening the bottom part of the window help?

7. To keep hot drinks hot, you put them in an insulated jug. To keep cold drinks cold, you put them in an insulated jug. How can this be? How can the same container keep drinks hot and cold?

8. When a fire is built in a fireplace, the smoke rises up in the chimney. Why doesn't it sink to the floor?

Part I

Challenges

Challenge 1
Cool House

Challenge Objective

Construct a roof that will allow the interior of the standard base to maintain the coolest temperature possible during a 3-minute heating trial. Materials are provided by the teacher but only combinations of two materials at a time may be used in any one trial.

Challenge Scenario

You and your team are shipwrecked! You're on an atoll (a tiny, flat, ring-shaped island with little or no plant life) in the North Pacific Ocean, just above the equator. It is very hot, and no trees or plants grow on the atoll to provide shelter from the Sun.

The remains of a very large packing crate perched on its side lie at the far end of the beach. Its previous contents, food and other items, are scattered along the shore. The bottom and three sides of the crate are still intact, but the side facing up is gone. It is too heavy to be moved or turned over. Your goal is to use the materials that have washed up on shore to construct a flat roof that will cover the crate so that the temperature inside will remain cool under the hot Sun.

Materials

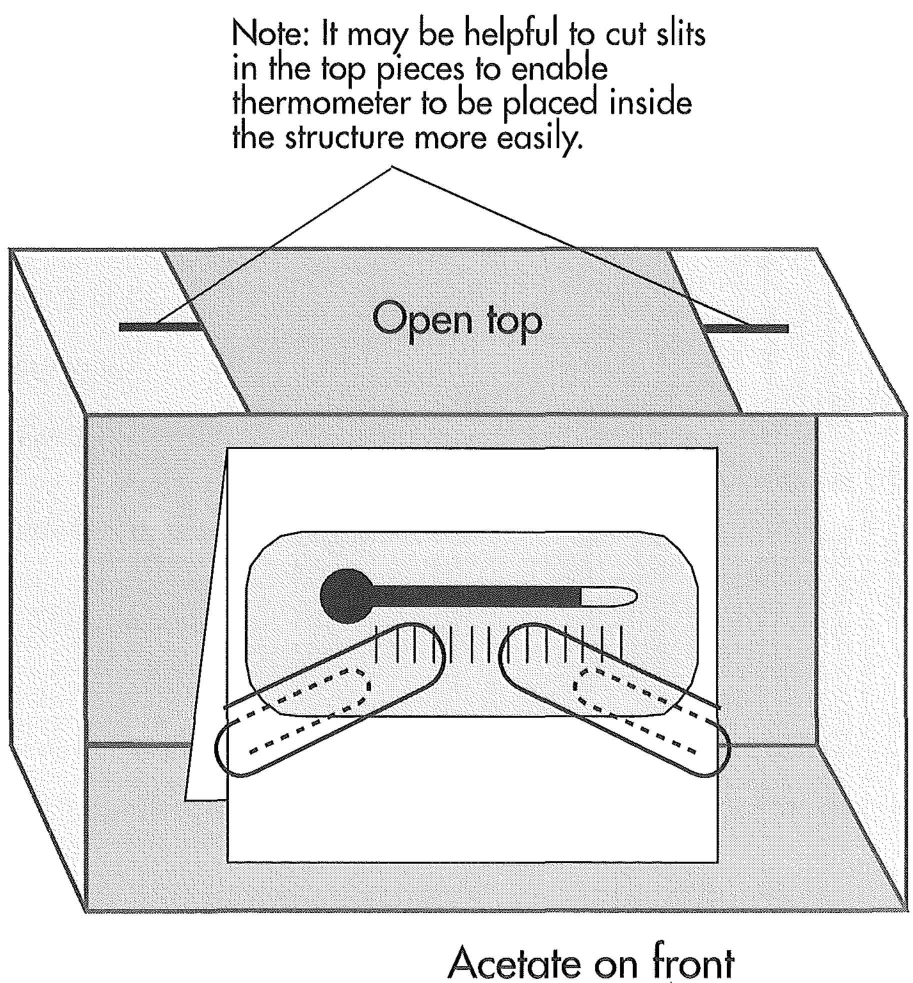
- Aluminum foil, 3 × 5 inch (7.6 × 12.7 cm) pieces
- Balsa wood, 3 × 5 inch (7.6 × 12.7 cm) pieces, 1/8 inch (3 mm) thick
- Styrofoam™, 3 × 5 inch (7.6 × 12.7 cm) pieces, 1/8 inch (3 mm) thick
- Paper, various qualities and colors, 3 × 5 inch (7.6 × 12.7 cm) pieces
- Cardboard, corrugated and plain, 3 × 5 inch (7.6 × 12.7 cm) pieces
- White Index cards, 3 × 5 inch (7.6 × 12.7 cm) size
- Cellophane tape, 3/4 inch (2 cm) (one roll per team)
- Overhead transparencies or clear acetate sheets cut into 3 × 5 inch (7.6 × 12.7 cm) pieces (at least one per team)
- Preliminary Data Sheet (one per team)
- Design Sheet (one per team for each design)
- Data Sheet (one per team for each design)
- Summary Sheet (one per team)

Cool House

TEAM NAME: **DATE:**

You must build and test at least three different roof designs.

1. Build a shelter base by carefully following the directions in the diagram. You will recycle this base for all of the designs in this challenge.
   - The shelter must cover the standard base as shown in the diagram. You may not trim the 3 × 5 inch (7.6 × 12.7 cm) plastic piece to a smaller size.
   - The thermometer must fit inside the shelter so that you can read it from the outside without disturbing the base.



2. Individually test all of the roof materials provided by your teacher. You must note the starting temperature, then the temperature after three minutes. Record the results of your test in the table below, and calculate the difference in temperature between the start and the end of the test. This difference is known as ΔT (delta T).

Roof material	Start Temperature	End Temperature	ΔT
Aluminum foil			
Corrugated cardboard			
Black construction paper			
Yellow construction paper			
Styrofoam™			
Balsa wood			
Cardboard			
Clear acetate			

Cool House

TEAM NAME: **DATE:**

DESIGN ITERATION #:

1. Construct a roof out of the approved materials. The roof and shelter should meet all of the following criteria when assembled:
   - The flat roof can measure no larger than 3 × 5 inch (7.6 × 12.7 cm).
   - You may combine two types of materials in any single roof design.
   - Each test roof must use the same standard base.
   - There must always be a 9 inch (22.9 cm) clearance between the bulb and the top of the roof. If necessary, adjust the lamp height to maintain this clearance.
   - Place the shelter on the testing platform directly beneath the heat source and do not move it during testing.
2. Sketch your design. Label the types of material used for the roof.

3. Describe your design.

4. How is it different from your previous design?

5. What do you think the total temperature change between the start and the end of the test will be?

Challenge 1: Data Sheet

Cool House

TEAM NAME: **DATE:**

DESIGN ITERATION #:

1. Test your design. Use the data table below to record the test results at 30-second intervals:

Material A: ______________

Material B: ______________

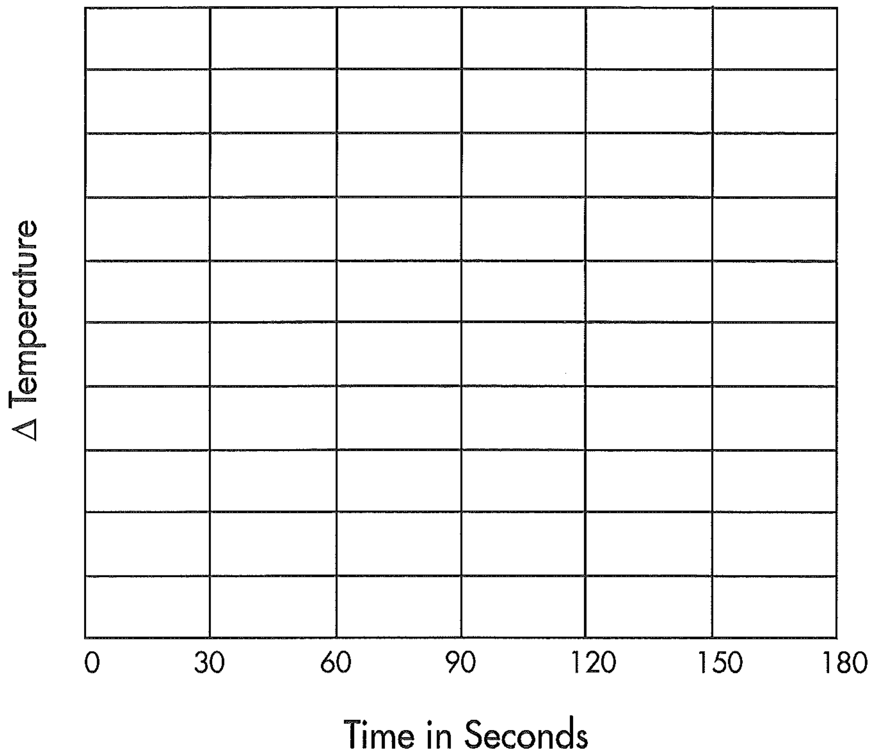
TEST RESULTS	Temperature	ΔT (Change from initial temperature)
Start		
30 seconds		
60 seconds		
90 seconds		
120 seconds		
150 seconds		
180 seconds		

2. What was the final value of ΔT from the time you started the test to the time that it was completed?

____

Write this number on the roof of the model.

3. Make a line graph of your temperature data. Remember to label the vertical axis.



4. Describe how or why the design succeeded or failed.

____

____

5. Was this design an improvement over the last design? Explain how it was or was not an improvement.

____

____

6. Please display your design and graph for other students to see.

Challenge 1: Summary Sheet

Cool House

TEAM NAME: **DATE:**

Record the data from all of your tests in the table below.

Design version	#1	#2	#3
Initial temperature			
Final temperature			
Temperature change (ΔT)			
Duration of test			
Was there an improvement over the previous design?			

Answer each of the following questions based on your designs.

1. Which material worked best? ______________
2. Explain why this model worked best.

____

____

____

3. If your best shelter kept heat out, where did that heat go?

____

____

____

4. Did you use a conductor in your best design? Identify it.

5. Did you use an insulator in your best design? Identify it.

6. Compare your best design to another team's best design. Name of other team:

A. How are the designs alike? How are the designs different?

B. Which design would be best suited for an island near the equator? Explain your answer.

C. If you could combine ideas from both teams, draw a picture of what the resulting shelter would look like. Do you think it would work better? Why or why not?

Challenge 2

Constant Temperature House

Challenge Objective

Build and test a series of roofs made from 3 × 5 inch (7.6 × 12.7 cm) index cards that maintain a cool temperature inside the shelter. The temperature should rise minimally during a 3-minute heating trial. Any type of roof design may be used, but maximum roof height may not exceed 6 inches (15.2 cm) from the top of the table.

Scenario Change

Now that you have created an effective flat roof, you realize that differently shaped roofs may keep the packing crate shelter even cooler. Large sheets of cardboard were among the items stored in the crate. Your goal is to use the cardboard to create a roof shape that will lower the temperature as much as possible inside the crate and maintain it.

Materials

- Design Sheet (one per team for each design)
- Data Sheet (one per team for each design)
- Summary Sheet (one per team)
- White Index cards, 3 × 5 inch (7.6 × 12.7 cm) size
- Ruler (one per team)
- Scissors (one per team)
- Cellophane tape, 3/4 inch (2 cm) (one roll per team)

Constant Temperature House

TEAM NAME: **DATE:**

DESIGN ITERATION #:

You must test at least three different designs.

1. Construct a roof of any shape using index cards. The roof and shelter should meet all of the following criteria when assembled:
   - The roof height cannot exceed 6 inches (15.2 cm) from the surface of the table.
   - You may use as many index cards as you think necessary in your design.
   - Each test roof must use the same standard base.
   - There must always be a 9 inch (22.9 cm) clearance between the bulb and the top of the roof. If necessary, adjust the lamp height to maintain this clearance.
   - Place the shelter on the testing platform directly beneath the heat source and do not move it during testing.
2. Sketch your design. Show the top and side views (include measurements):

3. Describe your design.

4. How is it different from your previous design?

5. What do you think the total temperature change between the start and the end of the test will be?

Constant Temperature House

TEAM NAME: **DATE:**

DESIGN ITERATION #:

1. Test your design. Use the data table below to record the test results:

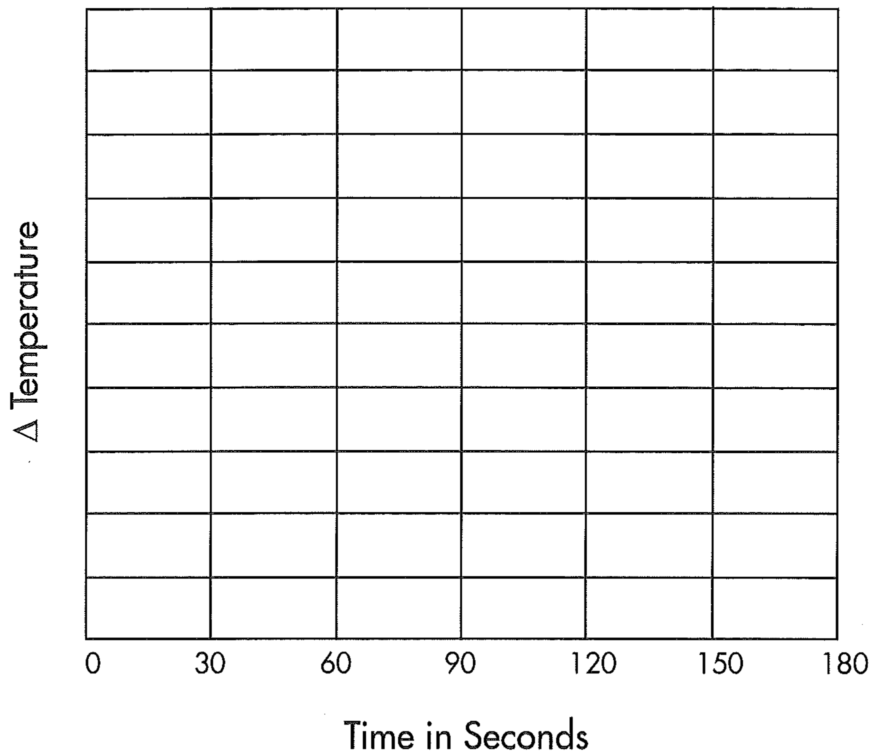
TEST RESULTS	Temperature	ΔT (Change from initial temperature)
Start		
30 seconds		
60 seconds		
90 seconds		
120 seconds		
150 seconds		
180 seconds		

2. What was the final value of ΔT from the time you started the test to the time that it was completed?

____

Write this number on the roof of the model.

3. Make a line graph of your temperature data. Remember to label the vertical axis.



4. Describe how or why the design succeeded or failed.

____

____

____

____

5. Was this design an improvement over the last design? Explain how it was or was not an improvement.

____

____

____

____

6. Please display your design and graph for other students to see.

Constant Temperature House

TEAM NAME: **DATE:**

Record the data from all of your tests in the table below.

Design version	#1	#2	#3
Time of test			
Initial temperature			
Final temperature			
Temperature change (ΔT)			
Was there an improvement over the previous design?			

Answer each of the following questions based on your designs.

1. Which design worked best? ______________________

2. Explain why this model worked best, using at least three of the vocabulary words.

3. If your best shelter kept heat out, where did that heat go? How did the design of your shelter help heat to flow in this direction?

4. Compare your best design to another team's best design. Name of other team:

____

A. How are the designs alike? How are the designs different?

____

____

____

B. Which design would be best suited for an island near the equator? Explain your answer.

____

____

____

C. If you could combine ideas from both teams, draw a picture of what the resulting shelter would look like. Do you think it would work better? Why or why not?

____

____

____

Challenge 3

Constantly Cool House

Challenge Objective

Using a variety of pre-approved materials, design any roof shape that will successfully keep the temperature as low as possible as well as constant for three minutes. There are no restrictions on style or material combinations although only two materials may be used at a time. You may use any available materials in any shape and combination that you choose. Maximum roof height may not exceed 6 inches (15.2 cm) from the top of the table.

Scenario Change

Your task in this challenge is to create a new roof for your shelter that will maintain the lowest constant temperature possible. Use your knowledge from the previous designs that you created to build a roof that will keep the house cool while maintaining a constant temperature for three minutes.

Materials

- Aluminum foil, 3 × 5 inch (7.6 × 12.7 cm) pieces
- Balsa wood, 3 × 5 inch (7.6 × 12.7 cm) pieces, 1/8 inch (3 mm) thick
- Styrofoam™, 3 × 5 inch (7.6 × 12.7 cm) pieces, 1/8 inch (3 mm) thick
- Paper, various qualities, 3 × 5 inch (7.6 × 12.7 cm) pieces
- Cardboard, corrugated and plain, 3 × 5 inch (7.6 × 12.7 cm) pieces
- White Index cards, 3 × 5 inch (7.6 × 12.7 cm) size
- Cellophane tape, 3/4 inch (2 cm) (one roll per team)
- Overhead transparencies or clear acetate sheets, 3 × 5 inch (7.6 × 12.7 cm) pieces
- Ruler
- Scissors
- Design Sheet (one per team for each design)
- Data Sheet (one per team for each design)
- Summary Sheet (one per team)

Constantly Cool House

TEAM NAME: **DATE:**

DESIGN ITERATION #:

You must test at least three different designs.

1. Construct a roof of any shape using the materials provided by your teacher. The roof and shelter should meet all of the following criteria when assembled:
   - The roof height cannot exceed 6 inches (15.2 cm) from the surface of the table.
   - You may use any of the materials provided, and can combine two materials if you choose.
   - Each test roof must use the same standard base.
   - There must always be a 9 inch (22.9 cm) clearance between the bulb and the top of the roof. If necessary, adjust the lamp height to maintain this clearance.
   - Place the shelter on the testing platform directly beneath the heat source and do not move it during testing.
2. Sketch and label the new design. Show the top and side views (include measurements):

3. Describe your design.

4. How is it different from your previous design?

5. What do you think the total temperature change between the start and the end of the test will be?

Constantly Cool House

TEAM NAME: **DATE:**

DESIGN ITERATION #:

1. Test your design. Use the data table below to record the test results:

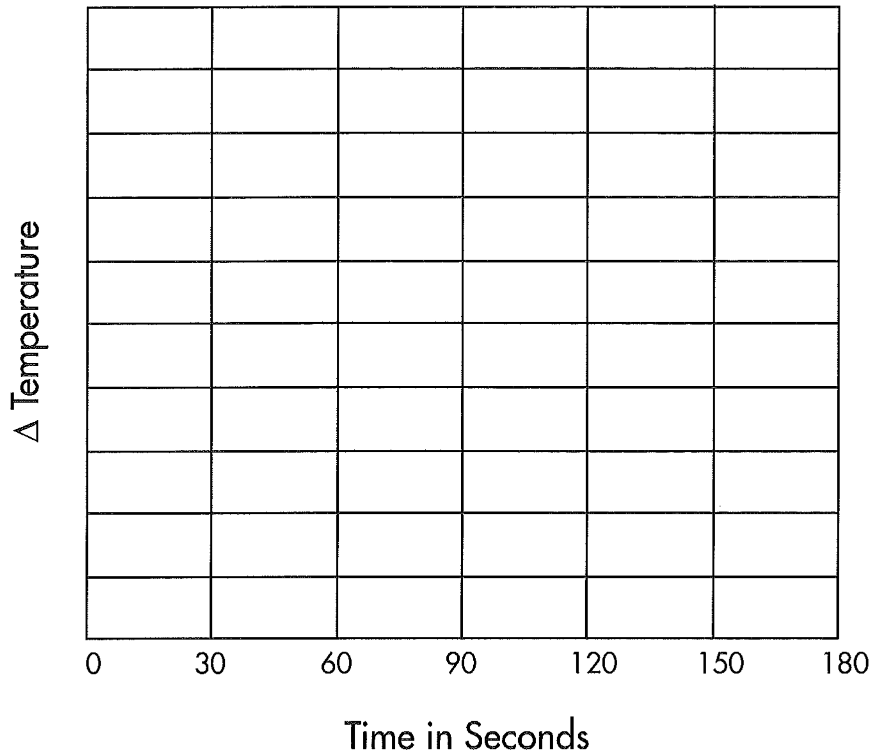
TEST RESULTS	Temperature	ΔT (Change from initial temperature)
Start		
30 seconds		
60 seconds		
90 seconds		
120 seconds		
150 seconds		
180 seconds		

2. What was the final value of ΔT from the time you started the test to the time that it was completed?

____

Write this number on the roof of the model.

3. Make a line graph of your temperature data. Remember to label the vertical axis.



4. Describe how or why the design succeeded or failed.

5. Was this design an improvement over the last design? Explain how it was or was not an improvement.

6. Please display your design and graph for other students to see.

Constantly Cool House

TEAM NAME: **DATE:**

Record the data from all of your tests in the table below.

Design version	#1	#2	#3
Time of test			
Initial temperature			
Final temperature			
Temperature change (ΔT)			
Was there an improvement over the previous design?			

Answer each of the following questions based on your designs.

1. Which design worked best? ____________________

2. Explain why this model worked best, using at least three of the vocabulary words.

____

____

____

3. If your best shelter kept heat out, where did that heat go? How did the design of your shelter help heat to flow in this direction?

____

____

____

4. Did you use conductors in your best design? Identify them.

5. Did you use insulators in your best design? Identify them.

6. Compare your best design to another team's best design. Name of other team:

   A. How are the designs alike? How are the designs different?

   B. Which design would be best suited for an island near the equator? Explain your answer.

TEAM NAME: DATE:

C. If you could combine ideas from both teams, draw a picture of what the resulting shelter would look like. Do you think it would work better? Why or why not?

Part II

Worksheets

Vocabulary

NAME: **DATE:**

Write definitions to the following terms in complete sentences and in your own words. You may use dictionaries or science books to help you with definitions. Use examples from the challenges that you have completed.

heat ______________________________

____

____

____

temperature ______________________________

____

____

____

energy ______________________________

____

____

____

solar ______________________________

____

____

____

convection

reflection

insulation

delta

radiant barrier

NAME: DATE:

conduction ______________________________

____

____

____

The History of Heating and Cooling Homes

NAME: DATE:

Answer the following questions in complete sentences.

1. How did the beehive house keep people warm?

____

____

____

2. In what part of the world do people live in igloos? What is the name of this group of people? What are their igloos made of?

____

____

____

3. How does a yurt keep heat inside?

____

____

____

4. In what type of structure did the Iroquois live?

____

____

____

5. How does a longhouse retain heat?

6. Why was the location of cliff dwellings important?

7. What is a megaron?

8. What helps many Mediterranean homes to remain cool inside? Why does this method work so well?

9. What is a clerestory? How does it work to cool a building?

NAME: DATE:

10. What is a climate control system, and what energy sources does it most often use?

____

____

____

11. Why are people combining modern ways of keeping their buildings cool with some of the older methods?

____

____

____

12. Why is insulation important? What does it do?

____

____

____

13. What is sustainable design?

____

____

____

14. Why are heating and cooling systems important to an astronaut?

____

____

____

Conduction, Convection, Insulation

NAME: **DATE:**

1. Look around your house or neighborhood and name a device that uses conduction to perform a task. Explain how it works.

2. Look around your house or neighborhood and name a device that uses convection to perform a task. Explain how it works.

3. Look around your house or neighborhood and name a device that uses insulation to perform a task. Explain how it works.

4. If the three devices that you listed above were made bigger or smaller, would that change how each works? Explain how it might for each.

A. ____

____

B. ____

____

C. ____

____

5. List at least two examples of ways to block or counteract solar energy. Explain how each example works.

A. ____

____

B. ____

____

Part III

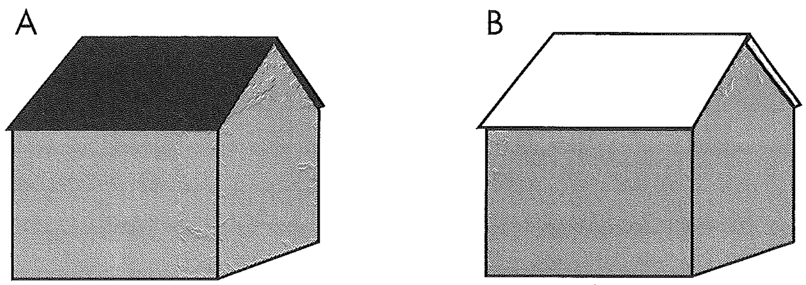
Assessment

Posttest

NAME: **DATE:**

Answer the following questions in complete sentences.

1. Which house will be hotter under the bright Sun?



2. Two cars are parked in a sunny parking lot. One is painted dark blue. The other is white. Which will remain cooler?

3. Two cars are parked in a sunny parking lot. One is painted dark blue and has open windows. The other is also painted dark blue and has closed windows. Which will remain cooler?

4. On a bright, sunny day, why is it cooler in the forest than in an open field?

5. It is winter in northern Canada. Jana is wearing a heavy wool coat. Kristi is wearing a light cotton shirt. Who will be warmer? Can you explain why?

6. It is a summer day in New York City. Jason goes home to a hot apartment. The windows in his apartment open on the top and the bottom. Jason opens just the top part. Then he puts an electric fan on the floor and turns it on. Why does he do this? Will opening the bottom part of the window help?

7. To keep hot drinks hot, you put them in an insulated jug. To keep cold drinks cold, you put them in an insulated jug. How can this be? How can the same container keep drinks hot and cold?

NAME: DATE:

8. When a fire is built in a fireplace, the smoke rises up in the chimney. Why doesn't it sink to the floor?

Assessment

NAME: **DATE:**

Answer the following questions.

1. Delta T (ΔT) is a measurement of ______________________________.
2. List examples of heat transfer by conduction, convection and radiation.

____

____

____

3. Describe how heat transfer can be measured.

____

____

____

4. Compare the three forms of heat transfer in terms of how heat "moves."

____

____

____

5. In which direction does heat energy travel, from hot to cold, or from cold to hot?

____

____

____

6. How does a thermos bottle keep things hot or cold?

____

____

____

7. When does conduction occur?

____

____

____

8. Insulation is only good for keeping things warm. True or false?

____

9. Vents in any structure that you are trying to keep cool are always a bad idea. True or false?______________

10. The following two teams performed Challenge 2: Constant Temperature House, and recorded these results for the 3-minute test period.

Team 1: Initial temperature 22°C

Time	Temp.	ΔT
30 seconds	22.5°C	———
60 seconds	23.5°C	
90 seconds	25.0°C	
120 seconds	26.0°C	
150 seconds	26.5°C	
180 seconds	27.0°C	

Total ΔT for test __________

NAME: DATE:

Team 2: Initial temperature 25°C

Time	Temp.	ΔT
30 seconds	25.5°C	———
60 seconds	26.0°C	
90 seconds	26.0°C	
120 seconds	26.5°C	
150 seconds	27.0°C	
180 seconds	28.0°C	

Total ΔT for test ___________

A. Using the tables above and on the previous page, calculate the ΔT for each team at each time interval, and the total ΔT.

B. Which team built the better structure? Explain.

11. What is the purpose of insulation?

____

____

____

12. Why is good insulation needed in both hot and cold weather?

____

____

____

13. Explain the difference between reflection and radiation.

____

____

____

Content/Concept Questions

NAME: **DATE:**

Answer the following questions in complete sentences.

1. Jack says insulation is only good for keeping things warm. What reasons would you give for agreeing or disagreeing with Jack?

2. Tanya says that holes in the roof of a dog house will help keep it cool in the hot weather. John says the holes will just let the hot air in. Which dog house design do you think will stay cooler if the Sun's rays are not shining directly on the house?

3. You can either heat the top, side or bottom of a container of water. Which heating location would make the water boil faster? Explain your reasoning.

4. One person sleeps outside under a starry sky while a friend sleeps under a tarp nearby. Who will be warmer?

5. Which would help keep a house warmer in winter, a black roof or a white roof? Why?

Self Assessment

NAME: **DATE:**

Answer the following questions.

1. Three things that I did not know before I did these challenges are:

   A. ____________________

   B. ____________________

   C. ____________________

2. Something that I thought was true at the beginning of the challenges which I now know is not true is:

   ____

3. One thing that I became better at doing during the challenges is:

   ____

4. One thing that I understand now which I did **not** understand at the beginning of the challenges is:

   ____

5. Something that I am proud of which I accomplished or learned during the challenges is:

   ____

6. Two questions that I had during the challenges were:

   A. ____________________

   B. ____________________

7. Two things that I still wonder about are:

A. ______________________________

B. ______________________________

8. Two things that I think I could have done better during the challenges are:

A. ______________________________

B. ______________________________

9. Something that I would do differently if I did the challenges over again is:

____

____

____

10. If I were the teacher and I could change one thing about the challenges, it would be:

____

____

____

Open-Ended Questions

NAME: **DATE:**

1. Draw two shelters that you would construct for this module. The design of one shelter will keep the heat from the Sun's rays out and keep the interior cool. The design of the other shelter should bring the heat from the Sun's rays in and keep the interior warm. After drawing the two diagrams, write a paragraph that explains what makes each shelter work.

Shelter A:

Keeping the interior cool

Shelter B:

Keeping the interior warm

2. When we purchase hot sandwiches, they are often wrapped in aluminum foil, then paper. Aluminum foil has reflective properties, but it is also a good conductor. Why would we use it to keep a sandwich hot? What is the paper wrapping on the outside for?