# Design a Building for Research Teams in Antarctica

**Summary:**

In this lesson, teams of three or four students will apply what they have learned about thermal energy, thermal energy sources, heat transfer, and the effectiveness of thermal energy conductors and insulators to design a research building for scientists working long-term in the extreme conditions in Antarctica. In addition, students will investigate the effectiveness of various insulating materials to determine which would be the best choice to use for their building design and Antarctic location. The building will be designed as a permanent structure, rather than a temporary camp shelter.

Students will accumulate background information related to Antarctica's geography, weather, year-round temperature extremes, frequent strong winds, shortage of exposed land or rock space on which to build, available energy resources, and scarcity of local building materials. Being aware of these factors, students will carry out investigations to determine the type of building to design, where and how the materials for the structure could be obtained, which insulation would be most effective, and where to obtain the insulating materials. Students will use their design drawing to construct a model of the building. The drawing should be clear, neat, and include critical details that readily depict the extreme-environment features of the structure and materials that will be used build it. Students will present their final project to you and the class, including the design drawing and the model they build, as well as a demonstration of their investigation of insulators with explanations of their methods and findings.

Several permanent research facilities currently exist in Antarctica. The severe cold, barren ground, and scarcity of needed resources in Antarctica make careful preplanning a necessity. The issue of greatest importance is how to maintain an acceptable temperature in the building so that scientists can do their work and live there. Therefore, the central focus of this activity is to design and build a model of a scientific research building that will minimize loss of thermal energy (heat transfer) by resisting the strong winds and cold outdoors of Antarctica.



Students will conduct research on conditions in Antarctica and devise a procedure and run tests that investigate the effectiveness of various building materials and thermal insulators. Then students will produce a poster drawing of their building design using clear markings and explanations of their plan. The team will also use their drawing to design and carry out a plan for investigating the effectiveness, safety, and availability of thermal insulators that would be best to use for their model structure. Each team will give a five- to ten-minute presentation of their proposed design and the model they built, as well as detailed explanations of what features make it a good plan for an Antarctic location. Students should answer these questions:

- What important factors related to thermal energy and heat transfer would make your design function as an efficient structure for housing a scientific research facility in Antarctica?
- What evidence does your investigation provided to support your choice of a specific insulator for your building if it were to be constructed in Antarctica?
- What features of your design plan and model would help the structure withstand Antarctica's strong winds, considering both resistance to thermal energy loss and structural wind damage?

**Estimated duration:**

**One week of class time** for project (students may also work on these at home) followed by one or two days of presentations. This time may vary because of other classroom factors and schedules, as well as by student readiness.

**Total:**

**Six to seven class periods** will be needed for project planning, research investigations, designing, building, and presenting their models.



- **Two class periods** should be spent forming teams; explaining and discussing the required research about Antarctica; researching structures, thermal energy loss (heat transfer), and thermal insulators/conductors; deciding on a building design; choosing a way to create the detailed design drawing; determining what materials and tools will be needed for team thermal energy and heat transfer investigations and presentation; determining what materials and tools are needed for constructing their model; determining where and how to acquire the needed items; assigning tasks for each team member; and planning how the team will work efficiently and cooperatively. Students should record their progress and plans in their journals.

- **Homework or study-center time** should be used to find information about examples of structures that currently exist in Antarctica (drawings and explanations) that fit a situation similar to those required for their design plan and model. The team will study and discuss these findings. Computer-assisted communication among team members would likely enhance this work and save time.

- **One class period** should be used for brainstorming and planning. Teams will begin to create a drawing for their chosen building design, as well as a plan for investigating various thermal insulators and conductors, and how to build their model. Teams should determine where to obtain specific building materials and tools and record their progress and plans in journals. Some homework time might also be needed and assigned as the team deems necessary (such as doing online searches, brainstorming ideas, making a list of needed materials, and looking around home for common examples of insulated items or materials useful for insulation applications, such as picnic coolers, cold or hot drink mugs, refrigerators, car floors, clothes dryers, house walls, and so on).

- **Three to four class periods** should be spent investigating the effectiveness of several types of thermal insulating and conducting materials. A simple method is to check the temperature change of hot water contained in various types of insulators or conductors over a period of time (e.g., a foam cup or insulated mug vs. a stainless steel or thin plastic cup). Students should investigate how to streamline their building so that Antarctica's strong winds will "slide by", thereby having minimal effect on loss of thermal energy (heat transfer) and damage to the building. In this time, teams should complete their drawings and investigations of thermal insulators versus thermal conductors, and their model structure. Students may need additional homework or outside-of-class time to complete these tasks. Students should record their progress and plans in their journals.

- **One or two class periods** should be used for teams to present their projects to the class.

## Teacher Content Background:

The information below should be shared with students as they begin to consider the design of their Antarctic structure, to investigate building materials, and to plan to build their model structure. Topics in this lesson include thermal energy; heat transfer; thermal insulators and conductors; and temperature, wind, and geographic conditions in Antarctica.

Below is an example of building design and insulation for retaining thermal energy in the severe conditions of Antarctica.

### The Princess Elisabeth Research Complex

The Princess Elisabeth Research Complex, designed in 2007 and built in 2009 by Belgium, includes the research station, some research and storage facilities, and several electricity-producing wind turbines. Since Antarctica has almost no construction resources, materials were obtained from suppliers around the globe.

The base of the structure is made of steel, which supports the main wooden structure. The steel base is fastened to the uneven bedrock (composed of granite) with rods that are nearly 10 meters deep to provide protection from the severe pushing and lifting effects of the strong Antarctic winds. The walls and roof of the structure are made of a heavy paper covering with an aluminum vapor barrier, thick wood panels, a foam layer, heavy wood posts, and steel plates. Steel and wood structural materials, along with insulation and vapor barriers, are placed around the walls, within the roof structure, and beneath the floors for minimal loss of thermal energy, reduced wind damage, and prevention of surface condensation.

Because of the lack of building resources and materials in Antarctica, all necessary materials to build the Princess Elisabeth Research Complex were gathered in other locations around the world. The necessary materials were shipped to Belgium and assembled there to form modules. The modules and miscellaneous parts were then shipped to the Eastern Antarctic location for final assembly.

The construction site is close to the ocean for several reasons. The rock outcrops occur only along the edge of the continent and are essential for anchoring the structure to Earth. There are no maintained roads in inland Antarctica, nor any efficient modes of transportation to haul the massive modules and parts across the vast ice and snow. Even if trucks or similar vehicles were brought in, there would be no available roads to follow or sources of fuel to operate the heavy-duty vehicles. Buildings, small temporary settlements, and research centers are generally located near the coasts because of the severe and isolated conditions inland.



**Related Concepts and Definitions:**

**Thermal energy** is the internal energy of motion of the atoms or molecules of a material. The greater the motion of these particles, the greater the thermal energy of the material will be. In nature, thermal energy always moves from hot to cold. That is, a warmer material will transfer its thermal energy to a nearby cooler material until they are at the same temperature. Only when some energy-driven mechanism is applied can thermal energy be moved from cooler to warmer surroundings, such as in an electric refrigerator, which pumps thermal energy from its already cool compartments to the warmer surroundings, usually to the kitchen air.

**Temperature** is a measure of thermal energy. In general, the greater the thermal energy of a material, the higher its temperature will be.

**Heat transfer** is the transfer of thermal energy from one place or material to another.

**Conduction** is the transfer of thermal energy from a warmer material to a cooler material when the materials are in contact with each other. For example, when a cold spoon is placed in a hot cup of tea, the spoon will get warmer and the tea will get cooler by conduction because the spoon and tea are in direct contact.

**Convection** is the transfer of thermal energy from one location to another when a warm object or material is actually moved, taking its energy with it. For example, when a mass of warm air moves across an area, it takes its thermal energy with it, making the area where it goes warmer.

**Radiation** is the transfer of thermal energy by way of electromagnetic waves called infrared waves. This type of heat transfer, unlike conduction and convection, does not require the presence of matter. That is, the energy can travel through empty space. For example, thermal energy from the Sun travels through space as infrared waves and heats Earth.

**Thermal insulators** are materials that prevent thermal energy from easily transferring to another area. For example, blankets are fairly good thermal insulators because body heat does not readily transfer away to the surroundings. Foam cups are good thermal insulators because the thermal energy in hot drinks is not readily transferred to the surroundings. Trapped air is a good insulator, and is the principle applied to double-pane windows, in which a layer of air is trapped between the two glass panes. Even snow can serve as a fluffy-blanket insulator because it contains trapped air, which helps hold in Earth's warmth.

**Thermal conductors** are materials that thermal energy easily moves through. Most metals, such as silver, gold, iron, copper, brass, and steel, are good thermal conductors.



**A nunatuk** is a small area of rocks emerging from ice sheets and is present in very few locations in Antarctica, generally near shorelines. Antarctica is deeply covered with ice and snow in most locations.

⚠ You will pre-approve student plans to investigate thermal insulators and conductors and monitor the students while doing the activities. You also will pre-approve any materials to be used in the investigation of thermal insulators and conductors.

**<u>Antarctica—A Cold, Dry Place</u>**

Antarctica, a continent at the southern tip of Earth, is surrounded by ocean water. The weather on other continents is modified by the thermal energy exchange between the water and land. However, the dry, cold conditions in and around Antarctica diminish the land-warming effect of oceans.

Nearly 100% of Antarctica is covered in snow and ice. As a result, about 75% of the Sun's energy is reflected back into the atmosphere, instead of being absorbed to warm the land. Cold air can't hold much moisture. So, the thermal energy radiated back into the atmosphere isn't held there, and is instead radiated into space. During Antarctica's winters, the size of the continent doubles as the ocean around it freezes. This increase in size blocks heat transfer from the warmer, surrounding ocean to the continent's inland areas.

Antarctica is at a high elevation, higher than any other continent on Earth, which contributes to its constant low temperatures. The average temperature is about –57°C (–70°F) in the interior regions and about –28°C (–18°F) along the coast.

The inland areas of Antarctica have rather calm winds that average 15 mph; but, the coastal areas average 150 mph throughout the year. Precipitation averages less than one inch per year. Low precipitation, very dry air, and extreme cold make the inland areas of Antarctica the world's driest desert.

The Sun and wind are the only significant energy resources in Antarctica. Many geologists theorize that there are abundant coal, oil, and various other mineral energy sources far beneath the surface of Antarctica. However, they are unreachable with current technologies. Also, there is a worldwide agreement that destructive mining or other damaging activities are not allowed on Antarctica, as it is considered the last remaining natural environment on Earth. All scientific research is closely monitored to prevent environmental damage.



**Before You Begin**

1. Help students understand the basics of thermal energy, such as thermal energy transfer (heat transfer), thermal conductors, and thermal insulators. Include a reminder about the particles that make up all matter—atoms—and that atoms form molecules of matter. It is the movement, or vibration, of these particles of matter that are responsible for the thermal energy level of all matter (including objects, such as spoons and books; materials, such as sheet metal and cloth fabric; and substances, such as water and air.)

2. Help students understand the kinds of thermal energy transfers that are likely to occur in everyday situations, such as in houses, school buildings, and outdoors.

3. Create a list of vocabulary terms. Examples include: thermal energy, atoms, molecules, thermal insulators, thermal conductors, types of insulation, thermal energy transfer (heat transfer), weather and climate conditions (specifically Antarctica compared to North America), hot deserts (such as the Sahara) compared to cold deserts (such as Antarctica), continents on Earth, anemometer, temperature, thermometer.

4. Give examples of common situations or applications of insulators to minimize thermal energy transfer (picnic coolers, hot or cold drinking mugs, foam cups, fleece-lined coats

and vests, house insulation, car floor insulation, water-pipe insulation wrap, refrigerator door inner-layer insulation, and so on).

5. Clarify how students should keep a record of their work in a project journal. The project journal should include notes about the team's planning, design sketches, discussions, model-building procedures, to-do lists, time-line plan, individual team member tasks, and other important information for reference.

6. Help students think through a materials list. Determine what will be available in the classroom, and how to obtain other needs to complete and present their project.

7. Collect for students' use basic project supplies, such as duct tape, rulers and metersticks, beakers, hot plates, alcohol thermometers, and other appropriate items in your classroom or lab that students might request or need.



8. Prepare important information about safety and any special precautions that students must keep in mind to avoid accidents or injury while participating in this activity. Students must be informed of relevant safety issues and precautions when working with any kind of laboratory investigation or experiment. Precautionary measures should be taken to assure safety with the insulation materials being tested or used, such as fiberglass insulation, certain plastic materials, and possibly others. Labels on the original materials' packages usually point out proper handling and use. Lab tools, such as hot plates, beakers, ring stands, and alcohol thermometers, should be used properly. Students should not use mercury thermometers. Safety glasses should be worn at all times.

Consider the specific conditions or features in your classroom, student characteristics, class size, and other factors that may require special attention in terms of safety. Be clear about safe practices and proper use of tools and materials, as well as consideration for others in the room. If any work on this lesson is also done as homework, discuss safety expectations in the home also.

## Instruction and Information for Discussion:

**Day One:**

- This activity will involve student teams, of three or four students each, who will design and build a model of a science-research building to serve as a laboratory and living quarters for a team of scientists working long-term in Antarctica. Each team will make a poster of their design drawing, and then build a model of their science-research building. The design of the building will be appropriate for Antarctica, taking into consideration the extreme conditions on that continent. It will be necessary for each student team to research Antarctica and the challenges to human habitation there. Some form of insulation will be necessary as part of the building plans for a structure to accommodate humans in their work and living spaces, as well as to protect the structure itself from the elements. Therefore, each student team will design and carry out an investigation to determine what type of insulation would be best for their Antarctic building design, which they will then build as a scaled-down model. The investigation must be designed to provide data about the effectiveness of various thermal insulators and conductors, to consider cost and availability, and to determine if their best choice would be an appropriate application to their proposed building design and model.

- Explain that the focus on the building design, model building, and the insulation choice, will be specific to the proposed setting–Antarctica.
- During the last day or two of the lesson, each team will demonstrate and explain their design drawing, exhibit and explain the model they built, and demonstrate their thermal insulation and conductor investigation to the class.
- Discuss safety issues and expectations related to the project.
- Have a method for assigning teams of 3 or 4 students per team ready.
- Administer the pre-assessment (See Attachment A-1). Allow 15 to 20 minutes for students to complete the assessment. Explain that it is not for a grade, but rather to evaluate what they know and what things they need to know.
- Following the pre-assessment allow a few minutes for student comments and questions.
- Remind students to be prepared to keep a daily journal of work on their project. It can simply be three-hole punched paper in a three-ring binder.



- For homework or study-center time, assign an Internet search and report on Antarctica, the location and conditions in Antarctica, the types of habitable structures in Antarctica, and the types of thermal insulators and conductors.

**Day Two:**

- Use classroom computers, smart boards, or slideshow presentations to provide some examples of various building plans, some better suited to Antarctica than others. Searches specifically about science facilities and working or living quarters in Antarctica can provide good information. You might search terms such as “building in Antarctica,” “scientists’ camps in Antarctica,” “weather in Antarctica,” “Antarctica–the desert continent,” and others.
- Briefly discuss yesterday’s homework assignment.
- Follow-up with information and instructions related to the weak areas of essential knowledge, as revealed in the pre-assessment results.

- You may wish to use the Prior Knowledge Review Sheet and Planning Reminders Scoring Guide (Attachment B-2) for differentiating instruction and to assist as a review and learning guide. This guide may be helpful for class discussion, as well as any homework assignments.
- Students will get into their teams for about half of the class period. The teams should
  - organize their journals. Each student should keep a journal, but they work as a team.
  - discuss and record how they will begin this project. What is the goal? How will they work toward it? What is their time line? Where will the work be done? Will it be done several places and then come together?
  - begin a design process. Ultimately they need to plan for the building and the insulation testing and use.
  - determine the supplies that are available in the classroom and what else will be needed. Where can we get the other needed supplies? Who will get them?
  - plan for how to proceed during the next class time.

**Day Three:**

- Today you will do a “check-up” to see how the teams are coming along with their collaboration, research, brainstorming, planning, designing, obtaining supplies, and completing journal entries. They may even start some building design starter sketches.
- There will be opportunities as you move about for questions and answers, offering suggestions, and sharing with other teams as appropriate.
- Focus emphasis is on the activity and details of the project as a learning experience.
- Students continue to plan, design, make journal entries, and work toward their final project goals.
- Teams will arrange for any necessary outside-of-class work.



**Day Four:**

- Class time is used to continue improving building design, laboratory investigations of thermal insulators and conductors, recording in journals, collaborative drawing and constructing a model. Continue to stress the importance of safety.
- Use of class time is much the same as on day three. Students are also devising a team presentation plan. Use the following questions to help guide student activity. How will you demonstrate your project? Who will do what in your presentation? Will you need props other than your group’s poster, model structure, and insulation-investigation set-up? Is a presentation script needed? (If so, students should start to write it.) How will you have the right timing for the demonstration and presentation? (The limit is approximately 10 minutes.) During

this time, you are assisting by answering questions, providing suggestions, listening carefully to student input, and continuing to build students' understanding of content, while helping students to stay on task.

**Day Five:**

- Teams are putting the finishing touches on their presentations, posters, models and demonstration details. They may have had to redesign their buildings, as difficulties may have occurred. Journals should be up-to-date. They are aware of the scoring guide for the performance assessment (Attachment A-1) and are striving for a quality display of thoughtful practices in engineering design, collaborative work, measurements, calculations, data organizing and record keeping, as well as productive use of technology and clear communication. They are ready to present to the class on day six (or day seven if not all teams are able to present in one class period).

**Day Six:**

- Student teams present their final project. Ideally, there will be time near the end of the class for questions, answers and discussion.

**Day Seven (if needed):**

- Student teams present their final project. Ideally, there will be time near the end of the class time for questions, answers and discussion.

**<u>Differentiated Instruction:</u>**

- Students who physically struggle with handling tools and construction materials could focus on the design illustrations, input in planning, and verbal explanations, instead of the investigation or experimenting with thermal insulators and conductors or actual model building.



- Students who have difficulty organizing information (such as classroom notes and journal entries) could be supplied with graphic organizers. (See Example, Attachment D.)
- Students who struggle with reading or listening to instructions could be given a simplified step-by-step chart or list. (See Example, Attachment E.)
- Students who have not learned or cannot recall previous related content information could be assisted by classmates in discussing the illustrations, instructions, and descriptions in this lesson. (See Attachments A-1, A-2, B-1,B-2, and C.)

**Extension:**

- Provide opportunities for teams, or individuals from teams, to modify and improve the initial project they presented to the class.
- Provide opportunities for students to study Antarctica further by researching its environment or the world-wide political agreements and issues concerning Antarctica.
- Provide opportunities for students to gather and report on the specific kinds of scientific research being done in Antarctica today.

**Home Connections:**

Throughout this activity, students will have opportunities to look for examples of different types of insulation and insulated items in their homes (picnic coolers, insulated hot or cold drink mugs, insulated coats and vests, and others). This also provides an opportunity for students to think of ways they could save energy costs in their home.

**STEM Connections:**

This activity about thermal energy is focused on STEM science topics and issues. In order to do and understand the science, students apply mathematics knowledge and skills, attempt to improve understanding of engineering design and skills, and utilize the tools of technology to seek out information and make decisions about thermal energy transfer. In addition students should improve in 21st Century Skills, such as collaboration, communication, creativity, problem solving, technology literacy, and others.

**Career Opportunities Related to Structures and Human Survival in Antarctica:**

civil engineer, electric engineer, computer engineer, industrial engineer, research scientist, mathematician, environmentalist, computer-systems developer, energy-commission member, home-insulation services, HVAC (heating-ventilation-air conditioning) specialist, construction worker, geologist, hydrologist, meteorologist, anthropologist, materials engineer, medical doctor



**Attachments:**

Attachment A-1: Pre-Assessment

Attachment A-2:  Pre-Assessment Scoring Guide

Attachment B-1:  Prior Knowledge Review Sheet and Planning Reminders

Attachment B-2:  Prior Knowledge Review Sheet and Planning Reminders Scoring Guide

Attachment C:  Examples of Types of Insulation

Attachment D:  Journal Graphic Organizer

Attachment E:  Step-by-Step Flow Chart for Planning and Completing a Design and Construction Project

Attachment F:  Post-Assessment

**ATTACHMENT A-1**

## Pre-Assessment

Name: ____________________________________________ Date: ____________

1. The small particles that make up all matter are called ______________________.

2. Thermal energy is the internal energy of an object or any type of matter and is the result of the motion of its _______________ and/or __________________.

3. When an object or substance has high thermal energy, it will feel _____________ when we touch it.

4. When an object has low thermal energy, it will feel ___________when we touch it.

5. When we construct houses or other buildings, we try to keep the inside of the building warm in winter and cool in summer. To do this, we place various types of __________ __________ in the walls and inside the roof to minimize thermal energy transfer.



6. A material that is effective in reducing the transfer of thermal energy in or out of a building is called a thermal ___________________.

7. A material that is easily allows the transfer of thermal energy in or out of a building is called a thermal ______________________.

8. Thermal energy can be transferred from one place to another. We often call this process ______________ _____________________.

9. Antarctica is a large, cold, windy, dry, ice- and snow-covered continent. Average yearly precipitation there is less than one inch. It is called “the world’s largest desert”. Name two of these factors that would make it a desert. ______________________ and ____________________________________.

10. Consider the Antarctica factors mentioned above.
Identify two factors that would make it very difficult for humans to live there for months or years. ___________, _____________

ATTACHMENT A-2

## Pre-Assessment Scoring Guide

1. The small particles that make up all matter are called atoms.

2. Thermal energy is the internal energy of an object or any type of matter and is the result of the motion of its atoms and/or molecules.

3. When an object or substance has high thermal energy, it will feel warm/ hot when we touch it.

4. When an object has low thermal energy, it will feel cool / cold when we touch it.

5. When we construct houses or other buildings, we try to keep the inside of the building warm in winter and cool in summer. To do this, we place various types of thermal insulators in the walls and inside the roof to minimize thermal energy transfer.

6. A material that is effective in reducing the transfer of thermal energy in or out of a building is called a thermal insulator.

7. A material that easily allows the transfer of thermal energy in or out of a building is called a thermal conductor.



8. Thermal energy can be transferred from one place to another. We often call this process heat transfer.

9. Antarctica is a large, cold, windy, dry, ice- and snow-covered continent. Average yearly precipitation there is less than one inch. It is called "the world's largest desert". Name two of these factors that would make it a desert. dry and little rain fall (or barren, or long-term cold)

10. Consider the Antarctica factors mentioned above.
 Identify two factors that would make it very difficult for humans to live

there for months or years. Possible answers: extreme cold, ice or snow covered, ice covered land cannot support crops, lack of transportation systems because of the ice and snow

**ATTACHMENT B-1**

## Prior Knowledge Review Sheet and Planning Reminders

Name: ____________________________________________ Date: ____________

1. An atom is the basic particle of all ________________________.
2. The internal energy of substances and objects is called _______________ _______________.
3. Thermal energy of an object or substance is a result of the motion of ______________.
4. The measurement of thermal energy is _________________________.
5. The instrument generally used for measuring temperature is a ____________________.
6. We can make a descriptive design drawing of a proposed building ______________.
7. When thermal energy can readily be transferred through a material, that material is considered to be a good thermal ________________.
8. Materials that reduce the amount of thermal energy that readily passes through are thermal ________________________.
9. Four fairly common thermal conductors are __________, ____________, ________ ______________________, ______________________________.
10. Four fairly common thermal insulators are ________________,________________,______________________,_______ ______________
11. On a cold day, insulation helps keep thermal energy _____ a house.



12. On a hot day, insulation helps keep thermal energy ____________ a house.
13. When thermal energy is transferred from one place to another, the process is often called ________________________.
14. In nature, thermal energy always moves in the direction of ____________________.
15. In order to make thermal energy move from a cooler object to a warmer place (such as a refrigerator in a warm kitchen), some kind of device (such as a motor) must __________ the process, because it is opposite of the natural process.
16. Antarctica is actually considered to be a ______________ because of its extremely cold, dry, and barren conditions.
17. Scientists speculate that there probably are many resources deep beneath

the surface in Antarctica, such as oil, coal, and minerals; but, mining and drilling to find these resources have not been done because_____________________________________ and _________________________________________________________.

18. Scientists often set up temporary research camps to discover more facts about Antarctica. Biologists go there to study ____________________; geologists go to study ___________________________; meteorologists go to study ____________________.
19. There are just a few permanent buildings in Antarctica that were constructed for scientists to set up laboratories and living quarters for long-term research there. Some of the difficulties related to choosing a building design are
__________________________________________________,
________________________________,
_________________________________.

**ATTACHMENT B-2**

## Prior Knowledge Review Sheet And Planning Reminders Scoring Guide

1. An atom is the basic particle of all matter.
2. The internal energy of substances and objects is called thermal energy
3. Thermal energy of an object or substance is a result of the motion of atoms and molecules of the objects or substances.
4. The measurement of thermal energy is temperature.
5. The instrument generally used for measuring temperature is a thermometer.
6. We can make a descriptive design drawing of a proposed building plan.
7. When thermal energy can readily be transferred through a material, that material is considered to be a good thermal conductor.
8. Materials that reduce the thermal energy that passes through are thermal insulators.
9. Four fairly common thermal conductors are silver, copper, wet paper, thin fabric.
10. Four fairly common thermal insulators are fluffed fiberglass fibers, foam panels or cups, plastic bubble sheets, trapped air.
11. On a cold day, insulation helps keep thermal energy inside a house.
12. On a hot day, insulation helps keep thermal energy outside a house.
13. When thermal energy is transferred from one place to another, the process is often called heat transfer.



14. In nature, thermal energy always moves in the direction from warmer objects to cooler objects.
15. In order to make thermal energy move from a cooler object to a warmer place (such as a refrigerator in a warm kitchen), some kind of device (such as a motor) must force
the process, because it is opposite of the natural process.
16. Antarctica is actually considered to be a desert because of its extremely cold, dry, and barren conditions.
17. Scientists speculate that there are probably many resources deep beneath the surface in Antarctica (such as oil, coal, and minerals), but mining and drilling to find these resources has not been done because it is difficult or impossible to explore deep beneath the ice and snow and nations have agreed not to disturb the unspoiled environment there.
18. Scientists often set up temporary research camps to discover more facts about Antarctica. Biologists go there to study the few native living organisms; geologists

go to study the ice, snow and the few outcrops of rocks; meteorologists go to study the weather.

19. There are just a few permanent buildings in Antarctica that were constructed for scientists to set up laboratories and living quarters for long-term research there. Some of the difficulties related to choosing a building design are severe cold and freezing water supplies, strong winds that can cause thermal energy loss and damage to the structure, scarcity of choices for energy sources for electricity, and difficulty in fastening a building to the "ground," as almost everywhere is snow and ice covered.

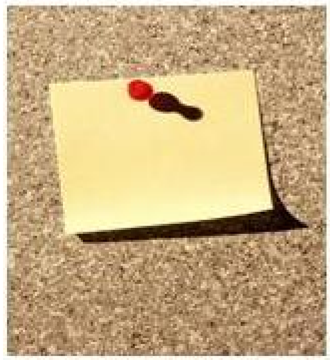
ATTACHMENT C

# Examples of Types of Insulation

## Home Insulation

## Thermos

**Cork**



**Foam Cup**

**Research Station in Antarctica**

**Space Shuttle**

**ATTACHMENT C—CONTINUED**

## Examples of Types of Insulation

| Type of Insulation | Common Uses | Significant Features |
|---|---|---|
| Foam sheets:<br>polystyrene or polyurethane | walls, floors, ceilings (unfinished) | very good insulator even when a relatively thin layer; can close gaps when installed carefully (common tools) |
| Sprayed-in foam:<br>usually polyurethane | existing (finished) walls or unfilled (open holes) in new walls | relatively easy to add insulation to an existing (finished) structure, closes in odd-shaped places (requires sprayer device and some skill) |
| Blanket batting (rolls):<br>fiberglass, mineral wool, | walls, floors, ceilings, | easy to lay out and install; fits standard between-stud distances |

| | | |
|---|---|---|
| plastic or natural fibers | attics (unfinished) | (common tools) |
| <br><br>Loose fill (blown in):<br>cellulose (treated shredded paper), fiberglass, mineral wool | existing (finished) walls;<br>or unfilled (open holes) in new walls | relatively easy to add insulation to finished structures; closes in odd shapes (requires blower device and some skill) |
| Reflective:<br>foil-covered paper, plastic film, or polyethylene bubble sheets | walls, ceilings and floors (unfinished) | can install it yourself, fits standard stud spacing or you can trim (common tools) |

**ATTACHMENT D**

## Journal Graphic Organizer

## Systems & Poster Project; Simple Electric Circuits and Security System

| What we discussed… | What do we want to accomplish? | What did we learn? What needs to be done?<br>Who will do it? | How can we learn more? What supplies do we need? |
|---|---|---|---|
| | | | |

| | | | |
|---|---|---|---|
| | | | |
| <br><br>**Additional information we need:** | | | |

**ATTACHMENT E**

## Step-by-Step Flow Chart for Planning and Completing a Design and Construction Project

Description of project:

Title of project____________________________ Team members:__________,___________, ________________,_________________

Pre-planning, getting started, projected schedule to complete:

Comments on completed project and presentation, questions to consider, possible future redesign:

How are we doing? Progress and problems (with possible solutions):

**ATTACHMENT F**

# Post-Assessment

Each student team will explain to you and the class their Antarctic building design drawing, as well as demonstrate their investigation design by actually doing some testing of different thermal insulators and conductor materials. Presentations will include explanations of both their poster and their investigative procedures.

**Presentation Specifications and Grading Guide** Points should be assigned from 0–4 with 4 being the best possible score for each item below.

_____The poster for their design drawing is at least 16 inches by 20 inches, with the drawing fitting on most of the poster space so that it can be read by the audience in the classroom.

_____The design drawing is neat and carefully drawn to show the exterior of the building and the inside rooms.

_____The design drawing is clearly labeled and the explanation is thorough.

_____The investigation demonstration is carefully done, following all appropriate safety precautions.

_____The materials and equipment for the investigation demonstration are appropriate and used in ways that make good sense for the purpose.

_____ The design plan for the investigation is appropriate for finding answers to the questions being asked about thermal insulators and conductors.

_____The model structure follows the design plan and is a neat, clear representation of the intended plan.

_____The testing of the building for insulation efficiency and wind resistance were reasonable and clearly reported.

_____Students clearly explained how their project relates to conditions in Antarctica.

_____Each member of the team participated in the presentation.

_____The presentation is well planned and moves along smoothly.

_____The team members are well informed and demonstrate significant understanding about their project topic.



_____ The information presented is grounded in sound scientific principles.

_____The presentation includes evidence of the team's appropriate use of mathematics, technology, communication skills, science learning and reasoning, and team collaboration, as well as an awareness of the geology, weather, and other significant features of the Antarctic continent.