

KEEPIN' IT COOL (1 Hour)

In this activity, students will examine different types of insulation. They will create and test their own insulating "ice chambers".

OVERVIEW

Topic: Heat Transfer

Real-World Science Topics:

- An exploration of how to use the design process
- An exploration of the factors that affect the rate of heat transfer

Objective

Students will gain an understanding of the engineering design process by designing and observing different containers that slow down the process of heat transfer.

Materials Needed for Student Activity

Materials Needed for Teacher Demonstration

- ice cube
- paper cup
- stopwatch or egg timer
- small graduated test tube (or other small liquid measuring unit, like measuring spoons)

Materials Needed for Student Teams

- paper cups
- ice cubes
- clear tape or duct tape
- string
- scissors
- various insulating materials such as pieces of polystyrene foam (e.g. Styrofoam™), cotton balls, different types of fabric (e.g. cotton, polyester, or wool) newspaper, plastic wrap, cardboard, and aluminum foil.

Grades K-1:

- spoons (for removing ice)
- paper towel

Grades 2-3:

- small graduated test tube (or other small liquid measuring unit, like measuring spoons)

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Teacher Preparation

In advance of the activity, prepare a number of ice cubs using a standard-size ice cube tray. Try to get the water level as even as possible in order to make the pieces of ice relatively uniform shape and size.

Grades K-1: Decide how many groups you want to have for the activity and prepare a different type of insulating material to assign to each group.

Grades 2-3: Prepare a variety of insulating materials (a list of suggested materials is provided above) in advance of the activity. Each group of students will be able to choose up to three materials to use in creating their insulating chamber.

STEPS FOR *KEEPIN' IT COOL*

- 1. Warm-up Activity:** Tell students that they are going to use ice to learn about heat. Have each student touch a piece of ice. Ask them to describe how it feels when they touch it (e.g. “cold”, “hard”, “wet”). Explain that when an object feels “cold” to us, what we are actually experiencing is the flow of heat energy. Heat always flows from warmer objects to cooler objects. When an object feels cold, heat is being transferred from your body to the object. When an object feels hot, heat is being transferred from the object to your body.

Ask students what they think happens to the flow of heat when they put on a coat on a cold day. Explain that the coat is an insulator—a material that slows down the rate of heat transfer from the body to outside air. During this activity, students will use the design process to create an insulating “ice chamber” that will slow ice from melting.

- 2.** Tell students that they will be designing and building containers to insulate a piece of ice to slow down the transfer of heat from the ice to the outside air. Begin by demonstrating what will happen to a piece of ice that is exposed to the air without insulation. Place a piece of ice in a paper cup and let it sit for five minutes. At the end of that time, pour the liquid from the cup (excluding any remaining ice) into a graduated cylinder or other measuring device. Measure the amount of liquid. Tell students that the goal of the activity will be to discover what kind of insulation slows ice from melting so the amount that changes to liquid is reduced.

- 3.** Divide students into groups of 2-4. Give each group a paper cup to use as the base for their insulation chamber. Tell students that they should not close off the top of the cup because the ice cube will need to be put inside the cup for the trial.

Grades K-1: Assign each group a different type of insulation material to use when building their chamber. Then have each group construct an ice chamber by wrapping materials around the outside of the cup.

Grades 2-3: Give each group a copy of the *Keepin' It Cool* handout. Tell each group that they may have their choice of up to three insulating materials to use in their design. Then have each group construct an ice chamber by wrapping materials around the outside of the cup. Groups should complete questions 1 and 2 on the handout.

- 4.** Once groups have all completed their designs, give each group an ice cube. Tell them to drop the ice cube into their chambers when you say, “Go”. Set the timer for five minutes.

Grades K-1: At the end of five minutes, tell the groups to take the remaining ice out of the cups using a spoon, and place it on the paper towel. Then, one at a time, students should bring their cups up front. You will then measure out the water in each cup and write out the information on the board.

Grades 2-3: At the end of five minutes, students should carefully pour the liquid from their cups into the graduated cylinder and record the amount of liquid. Ask volunteers from each group to give you their results and write them on the board.

STEPS FOR *KEEPIN' IT COOL*

5. Determine the results of the trial. Which insulating containers had less water in them than the trial container? Which container had the smallest amount of water left after the trial?
6. **Wrap-up Activity:** Review and discuss the results of the activity. Which designs and materials worked best? Ask students why they think certain designs worked better than others did. Ask what they think they might do differently if they could do the experiment again. Have the groups in Grades 2-3 complete the remainder of their handouts.

Keepin' It Cool Extension Activities

Grades K-1: Have students complete the activity again, this time using two materials instead of one (you can assign them or have students choose). Ask how they think the results will be different from their first trial. Once you have repeated the trials, ask students how the results were different from the first test.

Grades 2-3: Have each group repeat the activity, but this time alter one variable of their choosing in order to see how the experiment changes. Possible variables might include increasing the amount of ice, changing the amount of time for the trial, or choosing a different environment in which to have the trial (e.g. a refrigerator or a cupboard). Explain to students that it is important to change only *one* variable at a time, in order to see the effects of that variable. Have students predict how the altered variable will change the results of the activity. Have students perform the trial again, and record their results. Determine how the results compared to their first trial. Ask students whether their predictions about what would happen during the second trial were correct.

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BACKGROUND INFORMATION

What is heat?

Heat is the energy transferred between objects at different temperatures. According to the second law of thermodynamics, heat always flows in one direction—from the hotter object to the cooler object. The process of heat flowing between objects is called heat transfer.

How is temperature different from heat?

Many people think that heat and temperature are the same. However, unlike heat, temperature is not a form of energy. Instead, it is a measurement of the average kinetic energy of the particles in an object. For example, take two objects made of the same material but have different masses. They are the same temperature, but the object with the larger mass has more heat energy.

Another difference between heat and temperature is how they are measured. Heat is measured in units called joules. One joule is equal to one Newton-meter (N-m), or one kilogram-meter per second squared ($\text{kg}\cdot\text{m}/\text{s}^2$). There are three different scales for measuring temperature: Celsius, Fahrenheit, and Kelvin. Both the Celsius and Fahrenheit scales use units called degrees and are based on the melting and boiling points of water. The Kelvin temperature scale works a bit differently. It is based on the thermodynamic properties of substances and uses units known as Kelvins. On the Kelvin scale, a temperature of zero is the lowest temperature possible. This is also known as “absolute zero”. At zero K, an object cannot transfer any heat to its surroundings.

What is thermal conductivity?

Thermal conductivity is the rate at which heat is transferred through an object. Conductivity depends on the physical characteristics of the object. Thermal conductors are materials that allow heat to be transferred quickly. Thermal insulators are materials that slow down the process of heat transfer. However, even the best insulators can only slow down heat transfer; they cannot stop it completely.

Engineers think about of the thermal conductivities of materials when designing containers and other devices. For example, most gases are good insulators if they are contained in one area which is why some containers are made with materials that have tiny air pockets.

How does the transfer of heat affect changes in state?

When a substance changes state, the amount of heat it contains also changes, even though the temperature remains constant. For example, when ice melts there is no difference between the temperature of the solid water and the liquid water. However, heat must be absorbed by the ice for it to change from solid to liquid. Similarly, when water freezes, it must release heat to change into ice. The amount of heat released or absorbed by a substance as it changes state is called latent heat.

Key Vocabulary

heat: the energy that moves from a hotter object to a cooler object

temperature: a measure of the kinetic energy of the particles in a substance

insulator: a material that resists heat transfer between two substances

conductor: a material that speeds up heat transfer between two substances

thermal conductivity: the rate at which heat energy is transferred through a substance

thermodynamics: the study of heat and energy in a system

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TEACHER HANDOUT

Before the trial:

Write down the materials you used to create your insulating chamber.

[Materials will vary]

What do you think will happen when you put ice in your container? Do you think it will melt faster or slower than the ice with no extra insulation?

Sample answer: I think the ice in my design will melt slower than the one in the demonstration.

After the trial:

How did the results of your design compare to the ice with no extra insulation? How did they compare to the results of your classmates?

Sample answer: My sample was different from those of my classmates. There was [more/less] water than in the demonstration. There was [more/less] water than in my classmates' designs.

Which design was the most successful? What was it made of?

Sample answer: The most successful design was made of [material(s)].

Come up with some ways that you might improve your design.

Sample answers: Using more insulating material; using a different type of insulating material

Insulators have many real-world uses. Think about a type of insulating device you have used in the past. What did it do, and why was it important?

Sample answer: A cooler keeps food cold during outdoor activities like picnics. It's important because it keeps the food from going bad.

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STUDENT HANDOUT

Name:

Date:

Write down the materials you used to create your insulating chamber.

What do you think will happen when you put ice in your container? Do you think it will melt faster or slower than the ice with no extra insulation?

How did the results of your design compare to the ice with no extra insulation? How did they compare to the results of your classmates?

Which design was the most successful? What was it made of?

Come up with some ways that you might improve your design.

Insulators have many real-world uses. Think about a type of insulating device you have used in the past. What did it do, and why was it important?
