Thermal Energy Transfer via Conduction Activity

Activity 2: Thermal Energy Transfer via Conduction

Objectives

- Students will be able to describe conduction as the process where thermal energy is transferred directly from one particle to another when the particles are in direct contact with each other.
- Students will be able to explain that insulation works to slow down heat transfer via conduction.
- Students will be able to compare the relative effectiveness of different insulating materials.

Time

- 45 minutes

Materials

- Insul-box®
- Sheet of aluminum foil same size as Insul-box®
- Standard heating pad
- Extra optional insulating materials (e.g., cellulose, foam board, fiberglass, foam)
- Infrared (IR) thermometer
- *Conduction* worksheet, page 52
- *Recommended R-Value Map*, page 61

Preparation

- The activity description below assumes that the Insul-box® is used as part of a whole-class activity. It can also be run as a station in combination with Activity 3 and Activity 4. In this case, the first group records initial temperatures and turns on the heating pad. Each subsequent group records a temperature while they are at the station. One copy of the worksheet is used for recording temperatures and is left at the station for each group to use.
- Fill each cavity of the Insul-box® with one of the types of insulation. One cavity should remain empty. Make sure to keep track of the color cavity that contains each type of insulation.

Procedure

1. To introduce conduction and insulation, ask students to put one of their hands palm down on their desks. Ask students to raise their hands if the desk feels cool or cold. Then ask students to raise their hands if the desk feels warm. Explain that if the desk felt cool they are transferring heat to the desk and if it felt warm the desk is transferring heat into their hands. Explain that this type of heat transfer is called conduction. This heat transfer occurs between objects (particles) that are in direct contact with one another. As an alternative or extension, students can pair up and touch their palms together instead of touching the desk. Ask students to indicate whether their partner's hand feels cool or warm.
2. Share with students that this type of heat transfer is critical in determining how much energy a home uses for heating and cooling. Describe that a furnace must work to replace the thermal energy that is lost, and that an air conditioning system must work to remove the thermal energy gained. Then explain to students that insulation is installed in walls, attics, and other locations. It works to slow down heat transfer by forcing heat or thermal energy to move through dead air spaces within the insulating material. Materials that are effective at slowing down the heat transfer are called insulators and materials that transfer heat effectively are called conductors. Ask students to brainstorm examples of conductors (e.g., a metal pot or pipe, or a glass window) and examples of insulators (e.g., a down coat, a pot holder, or carpeting).
3. Next, ask students to touch various surfaces in the room. Be sure to include metal surfaces. Ask students to share which surfaces felt cooler or warmer to the touch. Using the IR thermometer, measure the temperatures of these surfaces. You will likely find that these surfaces are close to the same temperature. Ask students why one surface would feel colder than another even though it is nearly the same temperature. After discussing, clarify to students that surfaces which felt cooler are conducting heat away from the hand more quickly because their molecules are closer together. This decreases the amount of trapped air spaces that slow down heat transfer.

CONTINUED ON PAGE 8

CONTINUED FROM PAGE 7

4. Discuss insulation and how it is used in a home to slow down heat transfer due to conduction. Describe various insulating materials and pass around samples of cellulose, fiberglass, and foam.
5. Introduce the activity by asking students, "What material do you think is the best insulation?" Listen to student answers and promote discussion. At this point, do not provide any answers or discuss how different materials work better in different situations. Allow for student discovery during the activity.
6. Explain to students that they will be working with an Insul-box® to experiment with different types of insulation and determine their relative insulating effectiveness. Show students the device so they can see that it has four cavities and is heated by a heating pad. Explain that they will not be able to see what is in each cavity, but that each cavity will either be empty, or filled with cellulose, fiberglass, or foam. Students will need to develop a hypothesis about what is in each cavity based on the temperature changes they observe.
7. Refer students to their worksheet's data table and explain how they will observe temperatures at 10-minute intervals. Once the readings are complete, they will calculate the total temperature change in each cavity.
8. Remind students that each cavity's initial temperature *should* be room temperature, but they might be slightly different. Unless the temperatures are drastically different this is okay. Since we are calculating the total temperature change, it does not matter what the initial temperature reading is.
9. Show students the IR thermometer and explain that when the button is pressed, the device measures the surface temperature of any object at which it is directed. Explain that the thermometer has a laser that is used to focus the sensor on the surface being measured. Looking into the laser can be harmful to the eyes, so the thermometer should never be aimed at someone above the neck.
10. Direct a student to aim the IR thermometer at the target for each chamber and direct all other students to record the temperatures on their worksheets.
11. Then, turn on the heating pad to the highest setting. Tell students to take readings at 10-minute intervals. Between readings, if they haven't done so already, they should also read the Building Envelope section on insulation in the informational text (page 38). Let students know that they will be given questions to answer based on the reading. Direct students to the *Recommended R-Value Map*, letting them know that they will need this resource to answer some of the questions.
12. Once all the temperature readings are complete, tell students to make predictions about what type of insulation is in each cavity. They should try to come to an agreement within their groups and then record the prediction(s) on the data gathering forms.
13. Begin by asking one student what cavity had the greatest temperature change, and ask them to predict what the insulating material is. Ask the student what information led him/her to his/her conclusion. Students should record their predictions on their worksheets and/or on the board. Establish that the uninsulated cavity should have had the greatest rise, demonstrating that any insulation is better than no insulation.
14. Reveal the type of insulation in each of the cavities.
15. Discuss the results and whether student predictions were correct. Ask students to share the reasoning behind their predictions.
16. Wrap up the discussion with the questions, "What do you think is the best insulation? Why might one use or not use a particular type of insulation?" Students should see that while some materials have a greater ability to slow down conductive heat transfer than others, some insulation types will work better than others in any given situation. For instance:
    - While foam insulates the best, it is the most expensive. So, in an attic, it might be impractical to install foam on the floor. Fiberglass and cellulose are more cost-effective choices.
    - In an empty (uninsulated) wall cavity, cellulose is an effective choice. Due to its properties, sprayed foam cannot be installed in an enclosed space such as this.