Keep It Cool

Lesson Plan

Teacher Notes

Background Information

When you put on layers to stay warm in the winter, or use a cooler to keep food cool, have you ever wondered about the science of thermal energy transfer? How *does* your insulated mug keep the liquid hot and how *does* your cooler keep food frozen? In fact, did you wonder how both of these devices can actually work to keep objects *hot* or *cold*? Many devices are designed to maintain the temperature of an object without being plugged into an electrical outlet, and even those that are plugged in, such as refrigerators, use designs and materials that reduce the effort needed to maintain the temperature, thus saving on resources

Ice cores are an example of a substance that needs to remain frozen when they are transported. Coring ice is one method used to measure atmospheric conditions. When layers of snow accumulate on a glacier or ice sheet, these layers trap air and dust from the atmosphere, which can be collected and measured by drilling an ice core. These ice cores are taken from remote places across the world, including alpine glaciers in the Andes Mountains and in the middle of the Antarctic ice sheet. When ice cores are drilled, they must be transported back to the Byrd Center in order to be analyzed and stored in the -20^{o}F freezer. In order to successfully transport the ice cores to the freezer, they need to be contained in a device that is lightweight, easy to carry in a backpack, and can keep an ice core below freezing for days. The devices is designed to reduce the transfer of thermal energy from the exterior (which can be warm as it travels on trucks and airplanes) to the interior. Many glaciers are also very bright because of their location above clouds and reflection of light off of the snow. So, the device needs to limit the transformation of light energy to thermal energy.

Using our knowledge of thermal energy transfer and transformation, our teams designed a container for storing and transporting ice cores. To prevent heat transfer into the cores from warmer air and objects surrounding the device, several layers of material are used to insulate the ice core. This includes three layers of cardboard and a layer of foam. This is very similar to how a high-quality cooler uses layers of plastic and foam to keep your beverages cold in the summer.

In addition to insulation, reflection also plays a role in preventing light energy that strikes the device from being transformed into heat transfer that would then warm the ice cores inside of the box. For example, black pavement on a sunny day will transform more light energy into thermal energy than white concrete. To prevent light energy on the glacier from transferred into thermal energy, the ice core container is wrapped in a reflective material, such as foil.

Although there are many ways to transport an ice core, utilizing our understanding of thermal energy transfer and transformation allows us to develop a cost effective, light, and efficient method for storing and transporting ice cores.

Instructional Goals

- Thermal energy is the energy contained in the random motion of the participles that make up an object. It can be transferred, like an oven or stovetop (via convection and conduction) or transformed from light energy, like the sun heating a driveway (radiation).
- A variety of basic materials can be used create a device that both insulates the ice core from thermal energy and prevents transformation of light energy into thermal energy.
- Ice cores are a tool that can be used to reconstruct the composition of the atmosphere and global temperatures throughout geologic time.
- Ice cores are drilled in remote locations, including ice sheets and alpine glaciers from all seven continents.
- These cores need to be transported great distances before being stored in a -20^{o}F ice core freezer.
- This activity includes an engineering/design challenge in which students design, construct, and evaluate the effectiveness of a device in solving a specific problem.

NGSS Standards

Elementary

4-PS3-2

Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

Common Core State Standards Connections

ELA/Literacy

R1.4.3

Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

W.4.7

Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8

Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information and provide a list of sources.

W.4.9

Draw evidence from literary or informational texts to support analysis, reflection, and research.

Middle School

MS-PS3-3.

Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.]

MS-PS3-4.

Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.[Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.]

MS-PS3-5.

Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.]

Common Core State Standards Connections:

ELA/Literacy

RST.6-8.1

Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.6-8.3

Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

RST.6-8.7

Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

WHST.6-8.1

Write arguments focused on discipline content.

WHST.6-8.7

Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

SL.8.5

Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

Materials Required to Create an Ice Core Device (for each group

- Sample Vial with a Frozen Core (approximately 50 mL)
- Plastic Baggie
- Napkin
- Packing Tape
- Newspaper
- Black Paper
- White Paper
- Cardboard
- Aluminum Foil
- Fleece
- Styrofoam

Materials Required for Planning

- 20-50 mL Graduated Cylinder for Measuring
- 3’ x 2’ Whiteboard or Chart Paper for Brainstorming and Sharing
- Marker
- Baking Sheet or Tray for Distributing Materials
- Location Where Devices Can Be Places for ~30 Minutes (ideally with sun exposure)

Detailed Instructions

Task 1: Thermal Energy Transfer and Transformation (varies)

Thermal energy is the energy contained in the random motion of the participles that make up an object. Before beginning this activity, students should understand how to measure thermal energy and be introduced to or familiar with thermal energy transfer methods, such as convection, conduction, and radiation. Thermal energy can be best described by comparing it to a convection oven, stove top, and microwave. This activity may also be done twice, once before students learn about these topics and a second time after they have learned about them. The performance of their devices and power of their explanations will hopefully improve.

Task 2: Ice Cores (5 minutes)

This can be done through a tour of the Byrd Polar and Climate Research Center, the ice core classroom activity, videos provided by the center or WOSU, or a brief lecture by the teacher. In addition to this material, the teacher can use their ice core device model and attached images to further explain the complexity of ice core research, drilling, and transportation and the importance of preventing thermal energy transfer in these processes.

Task 3: Creating and Sharing a Diagram (15 to 20 minutes)

Students should be evenly divided into groups. Group sizes of three students work best. Using the whiteboards, supplied materials, and knowledge of thermal energy transfer, the students should by given 10-15 minutes to brainstorm how to construct their ice core devices. Their drawing should be similar to a blueprint. The groups do not have to use every item in their model but should be encouraged to consider using as many items as necessary and useful. Groups should be encouraged to create detailed diagrams suitable for a presentation and use labels and different colors of markers, so their diagram is easily understood. Labels should outline how materials are used and how they will either reduce the transfer of thermal energy to the ice core (conduction or convection) or reduce the transformation of light energy to thermal energy (radiation). The teacher should not provide any recommendations on how to construct the ice core device but should remind students to reference recently-learned material about thermal energy. While materials should be available for inspection at the front of the room, groups should not be given materials to avoid their attention being focused too much on building rather than designing.

Once designs have been created, groups will be asked one at a time to share their whiteboard blueprint in 20 to 30 seconds. In their explanation, groups should have reasoning behind why each item is useful for building their device, referencing at least one of the following: conduction, convection, or radiation. It will be much easier for students to conceptualize conduction and radiation in this activity than convection and it is not essential to focus on all three.

<u>Task 4: Using the Diagram and Background Information to Create an Ice Core Device (10 to 15 minutes)</u>

In this task, groups will use their blueprints, the provided materials, and background information to construct their ice core devices. The materials for construction can be handed out directly to each group, or they can be passed out “grocery style”, where students come to pick up their own items.

After receiving the necessary items, the groups should be given their sample vial containing the ice core to be placed within their devices. The teacher should give the students 10 minutes to construct their devices with the provided materials. If a group did not use all the materials but find they need an item they missed, they are allowed to retrieve the item during the building process. Students should not, however, take more materials than allowed.

After ten minutes, the students should put their completed ice core device, with ice core inside, outside in the sun for 30 minutes. This outside deployment can be done on the second day of class. During this 30-minute time, the teacher will need to deliver another lesson. When the 30 minutes are over, remove the ice cores from their device and measure the meltwater from the thawing ice using the graduated cylinder. The group with the least amount of meltwater had the most successful device. The class should then discuss why the winning group’s device was successful and use this activity to describe the properties of thermal energy transfer and transformation.

Using their new knowledge of thermal energy transfer and after discussing the success of the winning group’s device, the groups should revisit their original design and write recommendations for revising their original device. These revisions should be shared with the class as a representation of the newfound knowledge.

Teacher Preparation Information

Before the classroom activity, the sample vials must all be filled with a consistent volume of water and placed in a freezer to create “ice cores.” The volume of water does not matter as much as long as they are consistent. From our experience, vials that accommodate 50 mL work well. Cardboard, fleece, and Styrofoam should be cut into 6 x 6” squares, while aluminum foil can be cut into 12” squares. Each group should have one of each of the required materials and three napkins. Teachers are encouraged to use materials from the recycling bin that are clean.

Images can be printed or displayed on a projector to better highlight ice cores drilling and research. Attached images include: a sample ice core created for use in a classroom, layers within a tropical glacier, researchers carrying the cores, and a transport box once it has been opened.

This activity is designed to introduce the topics of convection, conduction, and radiation or serve as a closing summary of thermal energy transfer and transformation. Additional resources, beyond lectures, can be used to learn about thermal energy transfer and transformation. We recommend using PBS LearningMedia or the Physics Classroom to cover thermal energy.

This activity complements a classroom activity about ice cores, which can be found on the Byrd Center website at https://byrd.osu.edu/create-classroom-ice-cores.

Supplemental materials can be accessed using the links below:

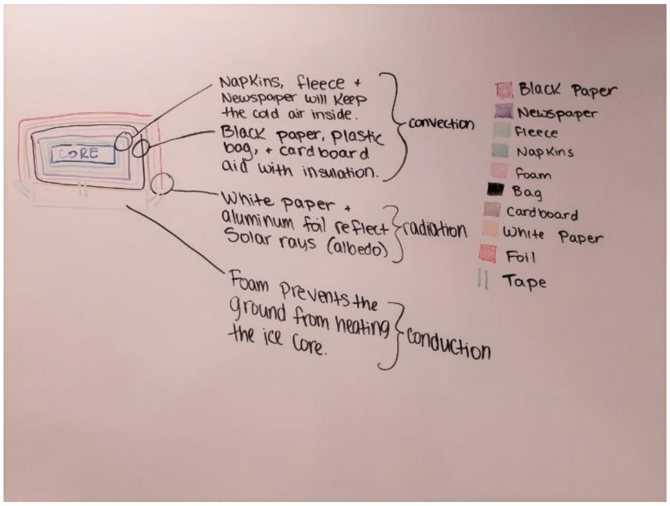
PBS: https://www.pbslearningmedia.org/resource/lsps07-sci-phys-thermalenergy/thermal-energy-transfer/
Physics Classroom: https://www.physicsclassroom.com/class/thermalP/Lesson-1/Methods-of-Heat-Transfer
Ice Core Activity: https://byrd.osu.edu/create-classroom-ice-cores

Photo Tutorial

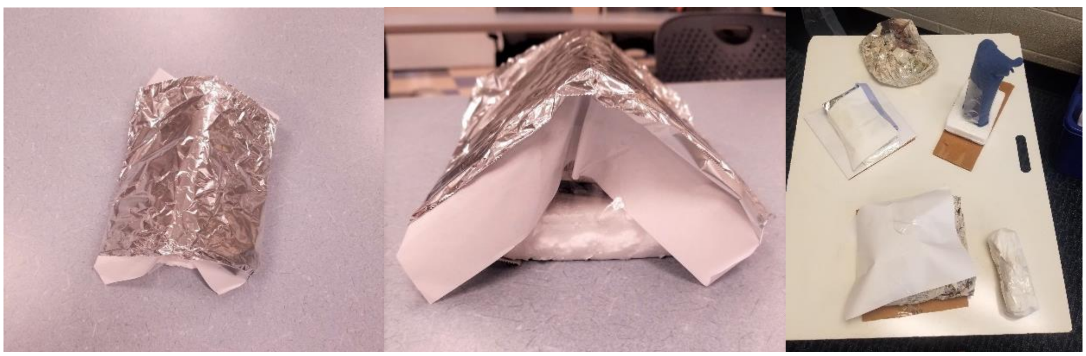
Step 1 - Materials:

Step 2 – Design:

Step 3 – Explain your reasoning:



Step 4 – Build!



Step 5 – Test and Evaluate