Introduction to Energy Transfer

Levels V-VI

Grades 9-12

Overview:

Students are introduced to the first law of thermodynamics and gain a basic understanding of energy transfer, thermal conductivity and conductive heat transfer.

Objectives:

The student will:

- use the words conductivity, conduction; and radiation in the context of energy transfer; and
- demonstrate an understanding of thermal conductivity and conductive heat transfer as it applies to Alaskan dwellings.

Materials:

- Tea kettle
- Burner or heat source to boil water
- Coffee mug
- Metal cup
- Drinking glass
- Styrofoam cup
- Fish bowl
- Index cards
- STUDENT WORKSHEET: “Energy Transfer in the Real World”

GLEs Addressed:

Science

- [9] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.
- [10-11] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.
- [9] SB2.1 The student demonstrates an understanding of how energy can be transformed, transferred, and conserved by applying the concepts of heat transfer (i.e., conduction, convection, radiation) to simple Alaskan dwellings.

Activity Procedure:

1. Explain that the ***first law of thermodynamics*** is also called the ***law of conservation of energy***. It states that energy can be transferred from one system to another, but it cannot be destroyed. This is important in the study of arctic climate change. For example, dark soils absorb much more solar energy (storing in the form of heat) than do snow and ice which reflect solar radiation. The energy stored in the soil will radiate out to warm the air, raising air temperatures.
2. Energy in the form of heat, electricity, motion, or sound can change forms and move from one system to another. This can be demonstrated by making a cup of tea. For example, electricity, one form of energy, changes form to thermal energy (heat) through the stove and it transferred by conduction to the water for tea. The cup warms the hands, and the tea warms the insides of the person drinking the tea. This is energy transfer.

3. Ask students to think of other forms of energy transfer (chemical to mechanical, such as gas to power snow machines; or chemical to thermal, such as heating oil to heat homes).
4. Explain that ***Energy transfer*** occurs when energy moves from one system to another. What happens when someone with really cold hands takes the hand of someone with really warm hands? Energy transfer! Heat travels from the warmer hand to the colder hand, until equilibrium is reached.
5. But what is really happening? Any time heat is transferred from one object to another, a physical process takes place. As an object begins to heat up, molecules within the object begin to vibrate. When this heated object comes into contact with a cooler object, energy is tranferred causing molecules in the cooler object begin to vibrate. As a teakettle warms up on a stove, the metal molecules that make up the kettle begin to vibrate. And as the water inside the kettle begins to heat up, the molecules that make up the water begin to vibrate too. As they vibrate, they move and expand. If they heat up enough, molecular bonds are broken resulting in the change of state to a gas and the water becomes steam. So transferring heat from one object to another occurs by molecular vibration. Therefore, holding hands with someone whose hands are warmer will cause a vibration to pass from one person to another. This is called ***conductive heat transfer***, the direct movement of heat between two surfaces that are touching. Ask students how licking a frozen pipe is an example of conductive heat transfer.
6. Do some mediums transfer heat better than others? This can be demonstrated by pouring boiling water into a metal cup, a drinking glass, a ceramic coffee cup, and a Styrofoam cup. Which transfers heat best? Which restricts heat transfer the best? Ask students to touch the rim of each container to see which transfers heat best.
7. The ability to conduct heat is called ***thermal conductivity***. A metal cup transfers heat quickly (high thermal conductivity), while a Styrofoam cup transfers heat slowly (low thermal conductivity). Ask students to name other materials with high thermal conductivity (all metals, glass) and with low thermal conductivity (wood, leather, etc.).

Critical Thinking Concept: The Fish Bowl Method. Hand out one index card to each student. Ask students to write down one question about the classroom lesson. They may ask a question that will help to clarify something they don't understand about the material, or they may ask a broad question about the subject and its real world application. Ask students to place their questions in a fish bowl and at the end of the class period or at the beginning of the next period, draw out several questions for class discussion.

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8. Ask students to complete the STUDENT WORKSHEET: "Energy Transfer in the Real World."

Answers:

1. Use the bear cave as a shelter, build a fire, use ice blocks, canvas and/or metal to block wind.
2. The snow cave will be the warmest, because snow has the least thermal conductivity and the thickest walls.
3. Conductive heat transfer will cause the hot wood stove to heat up the walls and burn down the cabin.
4. The smaller triple-pane window will reduce conductive heat transfer because it has as smaller surface area and air space between each layer.
5. Insulation reduces conductive heat transfer by creating a barrier between the cold outside and the walls, floor and ceiling inside.

Name:_____

Energy Transfer and the Real World

Student Worksheet (page 1 of 2)

Levels V-VI

Directions: Read the following information and answer the questions. Class discussion is encouraged.

Thermal conductivity is the ability of a substance to conduct heat. For example, a metal cup conducts heat more quickly than a Styrofoam cup. Remember: higher thermal conductivity means easier and faster heat transfer; lower thermal conductivity means heat does not transfer as easily or quickly.

Three friends from a local village are caught on an ice floe and carried far out to sea. As night falls they run aground on a deserted island, and while they have been successful in hunting a seal and have plenty to eat and matches to start a fire, they have no shelter. The temperature is already well below freezing, and a strong north wind is blowing. They need to find shelter fast.

On the island they find the following:

a big pile of dry twigs and sticks just above tide-line;

many chunks of sea ice piled along the shore;

a large, empty polar bear den dug deep into a snow bank near shore;

an old fishing shack made of sheets of metal roofing; and

an old canvas tarp.

1. What should they do to stay warm?

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2. What would be warmer, a snow cave or a metal shed? Why?

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Name:_____

Energy Transfer and the Real World

Student Worksheet (page 2 of 2)

Directions: Read the following information and answer the questions.

Conductive heat transfer is the movement of heat between two surfaces that are touching. For example, a pot of water has to be sitting on a hot stove burner in order for the water to boil. The heat from the stove heats the pan and the water in the pan through direct contact.

Uncle Sylvester is building a winter trapping cabin out by the lake. He is inexperienced, and he needs some help. Here is what he has done so far:

3. For heat he bought a cast iron wood stove. Because the cabin is really small, he plans to push the metal stove into the corner of the cabin, against the wooden walls. Explain to him about conductive heat transfer and why this is a bad idea.

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4. Uncle Sylvester bought two windows. One is a big window with a single pane of glass and the other window is smaller with triple-pane glass (that is, three layers of glass sandwiched together with a little air space between each layer). He only has wall space for one of the windows. Explain about conductive heat transfer and suggest what he should do to keep his cabin warmer in the winter.

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5. Uncle Sylvester has apparently forgotten all about insulating his metal roof and plywood floor and walls. Explain to him about conductive heat transfer and suggest how he can keep the heat in with good insulation.

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