6th Grade
Conduction, Convection, and Stored Heat Energy

Summary: Students 'feel' convection by melting an ice cube in their hands. They layer cold water, room temperature water, and hot water in a clear cup to observe that cold water is denser than hot water. Finally, students compare the amount of stored heat energy in wooden matches, a wax birthday candle, and an oily pecan.

Intended Learning Outcomes for 6th Grade:
1c. Given the appropriate instrument, measure length, temperature, volume, and mass in metric units as specified.
3a. Know and explain science information specified for the grade level.
4a. Record data accurately when given the appropriate form.
4b. Describe or explain observations carefully and report with pictures, sentences, and models.
4c. Use scientific language in oral and written communication.
4e. Use mathematical reasoning to communicate information.
5a. Cite examples of how science affects life.

Utah State Core Curriculum Tie:
Standard VI Objective 1:
a. Compare materials that conduct heat to materials that insulate the transfer of heat energy.
b. Describe the movement of heat from warmer objects to cooler objects by conduction and convection.
d. Observe and describe heat energy being transferred through a fluid medium by convection currents.

Preparation time: 45 min
Lesson time: 60 min
Small group size: Works best with one adult for every 5 students. Adults are needed to monitor the last experiment because it involves lighting matches and materials. The teacher can also do the final activity as a demonstration if adult volunteers aren't available.

Materials:
1. one ice cube per student, cubes should be equivalently sized; more ice is needed to make a pitcher of ice water for the convection activity
2. clear plastic cup, one for every two students
3. pitcher of room temperature water
4. pitcher of ice water with blue food coloring added
5. hot water from either a microwave, coffee pot, or pot heated on a hot plate; red food coloring to be added before use

6. Styrofoam cups
7. 15 30 cc or 50 cc plastic disposable syringes or plastic pipettes or eyedroppers; any parents in the medical or veterinary industries may be able to obtain plastic disposable syringes to donate to the class
8. empty soda cans, one per group of 5 students
9. 100 ml graduated cylinders
10. wooden matches, about 2” long
11. birthday candles
12. pecans
13. clay
14. paper clips
15. balance
16. thermometer that can fit into the hole of a soda can
17. aluminum foil

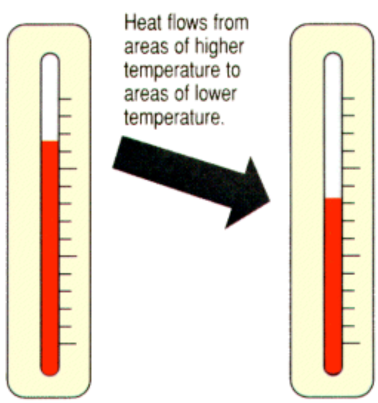
** optional material for a demonstration: Heat Conductometer, item #753418 from Carolina.com $15.95

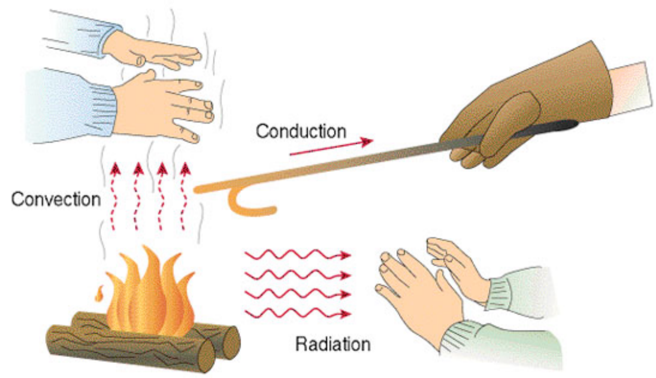
Preparation: The students if given enough time can perform the balancing of the three substances for activity 3, or the teacher can prepare the samples to be burned so that the lesson can be completed in one hour.

Take one birthday candle and cut off about .5 – 1 cm of the wax from the bottom. This reduces the time needed to completely burn the candle. Using a balance, determine how many wooden matches are equivalent to the mass of the birthday candle. Finally, balance a pecan against the birthday candle. It will probably take about half a pecan to equal the mass of the birthday candle. Use small clumps of clay and stick the birthday candle into the clay so that it stands up, stick the wooden matches into the clay, and stick a bent paper clip into the pecan and then stick the paper clip into the clay. For a class of 30, make two of each sample to be burned.

Background information:

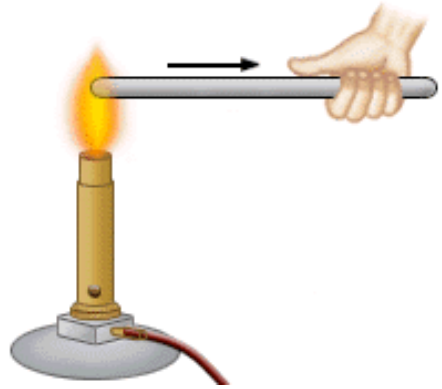
Heat transfer occurs between and within materials. Normally heat transfer occurs from a higher temperature object towards a lower temperature object. This transfer will continue to take place until the temperature is equivalent in both materials. Heat transfer occurs through three processes: conduction, convection and radiation.



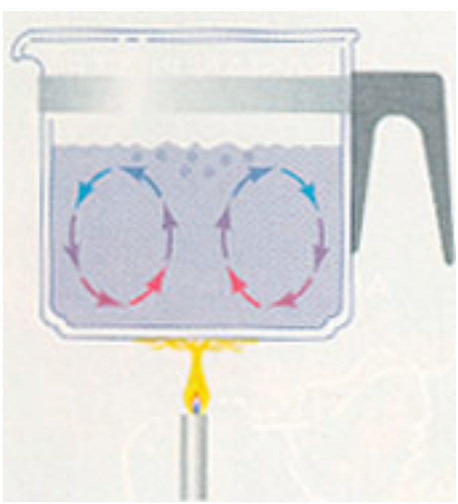


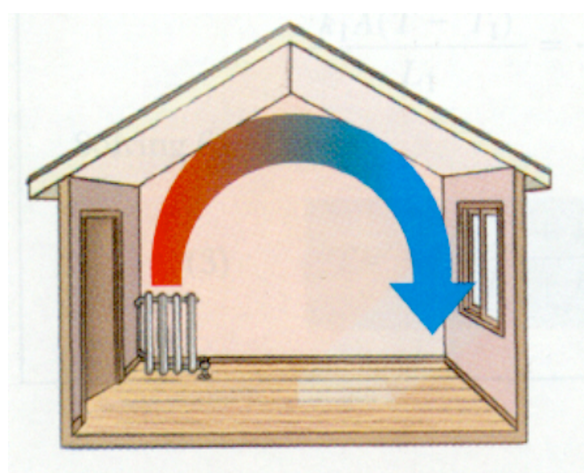
Conduction is heat transfer by means of molecular agitation within or between materials. Conduction occurs when two objects have direct contact with each other, heat energy moves between the objects because the fast moving particles in the warmer material transfer energy to the slower moving particles in the cooler material. Heat transfer continues until all the particles are moving at the same speed and both objects maintain the same temperature. An example occurs when you touch a hot pan and heat transfers from the pot to your hand. The higher energy particles in the pan hit the lower energy particles in your hand and heat energy moves from the pan into your hand. Conduction can also occur within one material, such as a metal poker placed within a fire. Conduction works best through **solids**.

Conduction is explored in two activities found in this lesson. First, when students melt an ice cube in their hand the faster moving molecules in their hand will transfer some of their energy to the slower moving molecules in the ice cube. The result is that the student's hands feel colder because the molecules in their hand are moving slower which reduces the temperature of their hands. Second, when students are burning their substances and the metal can is heating up the heat spreads from the bottom of the can up towards the top of the can by heat conduction. If the demonstration with the Conductometer is performed conduction is also seen as it varies in speed between 5 different metals.



Convection is heat transfer by mass motion of a fluid such as air or water when the heated fluid moves away from the source of heat, carrying energy with it. When particles are heated they move faster and their volume expands. As their volume expands the liquid or gas becomes less dense and rises. When the liquid or gas rises it begins to cool because it moved away from the heat source. The cooler particles move slower and the volume contracts. When the volume contracts, the liquid or gas becomes denser and sinks. This process of heating, expanding, rising, cooling, contracting, and sinking is a continuous one. This convection circular movement of water is how you heat up a pot of water. Convection occurs in **liquids and gases.**





Convection is explored in two activities in this lesson. First, when the different temperature liquids are layered, students will observe that the cold water is denser and sinks and the hot water is less dense and floats. While the three-layered waters are in the cup, the cold blue water will start to rise as it warms and the hot red water will start to sink as it cools. Eventually, the cup will contain water with a uniform color as the heat is evenly transferred due to convection.

Second, during the third activity, the water in the soda can will warm through convection as it is heated with the wood, wax, or oil.

All objects store heat energy and this energy can be released as the substance is burned. When a material is burned, the energy released can be transferred and used to heat water. The more the water heats up, the more energy that was stored in the material. A wax candle, wooden matches, and a piece of pecan have been balanced so that they are all equally massed to each other. Students can measure how much stored heat energy the materials have by measuring the increase in temperature of water in a can the samples are heating.

Pre-lab discussion: If the heat Conductometer was purchased from Carolina.com, follow the directions with the Conductometer and explain how heat is transferred down the different metals at different rates. Discuss insulators and conductors while performing the demonstration. Define the process of conduction and convection and explain the first two activities. Finally, ask the students if they were stranded on a mountain and they had a bag of pecans, a box of matches, or a candle; which of them should they burn to stay warm. Explain that they will answer that question today in Activity 3.

Instructional Procedure:

Activity 1: Conduction

1. Give each student an ice cube of the same size. Have them melt the ice cube by holding it in their hands. They can warm up their hands in any way but they have to use their hands alone to melt the ice cube. ** If students find the experiment too cold they can choose to stop melting the ice cube.

2. It is fun to have all the students start their melting of the ice cube at the same time and make the activity a race to see who has the 'hottest' hands in the class.

Activity 2: Convection

1. Students should work in groups of two. Each group needs a clear plastic cup filled 1/2 full with room temperature water. Water can be placed in a pitcher the day before the class so that it has time to come to room temperature.

2. Fill a Styrofoam cup one half full with blue ice water. Add the ice to the water about 30 minutes before class begins to be sure the water is very cold. Add ice if necessary to maintain the presence of ice in the water until the experiment begins.

3. Use a syringe to measure out 20 ml of ice water from the Styrofoam cup. (If syringes aren't available, students can still layer the liquids using pipettes or eyedroppers and adding the liquid VERY slowly.) Insert the syringe carefully below the level of the water and touch the tip to the inside of the cup. **Slowly** drip the blue water down the side of the plastic cup. Students should see that the cold ice water sinks below the room temperature water because it is denser. It is very important that the blue water is added very slowly or else too much mixing occurs and the blue water won't stay layered on the bottom.

4. Fill a Styrofoam cup one half full with red hot water. Measure out 20 ml of hot water in the syringe. Hold the syringe against the side of the cup, but above the water, and drip the water down the side of the plastic cup. Again, this needs to be done very slowly to prevent mixing. Students should see that the hot water layered on top of the room temperature water because it is less dense.

5. Have the students observe their layered water in the cup throughout the rest of the class period. Towards the end of the class period they can discuss why the colored layers are now mixing in their cup.

Activity 3: Stored Heat Energy – This activity should only be completed with adult volunteers helping each student group or as a teacher demonstration. Students should not be allowed to light the matches or conduct the experiment on their own.

1. Fill a soda can with 80 milliliters of room temperature water. Take the temperature of the water in the can and record it on the data table on their lab sheet.

2. For a class of 30 students, 6 groups is best for this activity. Each group responsible for one of the materials. Place the clay base, with material inserted into it on a piece of aluminum foil in the center of the table. Light the material.

3. Quickly hold the can over the flame. If the can is held near the neck at the top, the can doesn't get very hot and hands will not get burned. The bottom of the can should be just barely touching the flame of the object. As the flame changes in size, adjust the height of the can so that it is always just touching the top of the flame. It is important that each group keeps the flame the same distance from the can so comparisons can be made. If the flame blows out on any of the substances before it is completely consumed – light the substance again. Samples must be burned completely in order to accurately compare the results.

4. When the object is done burning, stir the water, and take the temperature of the water in the can.   Record this final temperature reading on the data table. Subtract the initial temperature from the final temperature to calculate the increase in temperature of the water from the burning of the material.

5. Discuss that the petroleum chemicals in the candle, the wood particles in the matches, and the oil in the pecan are burned to produce energy. Students can calculate which energy source produces the most energy per mass of the material. The object that raised the temperature the most - produced the most energy.

6. Either the birthday candle or the pecan will contain the most stored energy. If the birthday candle isn't burned all the way to the bottom, all of its energy won't be released and the temperature increase will not be as high as that of the pecan.