PSI: PHYSICAL SCIENCE INVESTIGATION

wviz ideastream℠

GREAT LAKES Science Center

Teacher's Lesson Description

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| Title | **The Heat Is On!** |
| Brief Description of the Videos | Heat transfer through metals is faster than through other materials. The transfer of heat can be noted when chocolate is used to monitor the flow of heat. In the videos, the bits of chocolate are placed at regular intervals on a copper pipe which is heated on one end by a Bunsen burner and shows heat transfer as the chocolate melts. Other samples of chocolate are placed on a metal baking sheet and heated from one end. Lastly, more samples are placed in two concentric rings on a circular metal baking sheet and the heat source is placed in the center. Heat is transferred by conduction only. Convection and radiation are not demonstrated. |
| Time Needed | One class period |
| Ohio Science Benchmarks Addressed | Physical Sciences Grades 6-8 Benchmark D |
| Ohio Grade Level Indicators Addressed | Grade 7 Physical Science Indicators 2 and 3 |
| Concepts Developed | Thermal energy: components of thermal energy are potential energy (possessed at the extremes of the motion of the particles); kinetic energy (possessed in the actual motion of the particles); the particle nature of matter (or kinetic molecular theory); random motion of particles at varying temperatures. |
| Lesson Rationale | Plants and animals live within a narrow range of temperatures required for their biological functions, so our immediate environment must have a fairly narrow temperature range as well. Human industrial processes use more widely varying temperatures, and the flow of thermal energy must be understood to understand how heat is used to create products from metals, alloys, |

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| | ceramics and other material compounds. This lesson helps students to discover how heat is transferred by conduction through matter. Convection and radiation are two other ways that heat energy is transferred through natural processes, and students should have some understanding of all three. |
| Background Knowledge for Teachers | Heat is thermal energy that flows naturally from areas of higher temperature toward areas of lower temperature. In order to reverse the natural flow of heat, as in refrigerators and air conditioners, work must be done, and generally requires other forms of energy, such as electrical energy. Understanding thermodynamics is facilitated by a model of matter consisting of particles which have random motions or vibrations. As heat is added the particles move more rapidly, or vibrate more. But as heat is taken away, or things cool, the particles move or vibrate less. Solids have particles that vibrate little and do not flow while liquids have particles that vibrate more and can flow, because of weaker bonds between particles. As more heat is added, the bonds become even weaker and the particles move about freely, as in a gas. So, whether matter exists in its solid state, liquid state, or gaseous state depends upon heat and the behavior of the particles within certain ranges of temperature. In these PSI demonstrations, thermal energy is transferred by **conduction,** which happens when objects and particles in direct contact with each other give some of the thermal energy from faster particles to more slowly moving particles.<br><br>By comparison, convection is heat transfer by movement of heated liquids or gases due to differences in density. It can be demonstrated by placing an ice cube in a glass of warm water and adding a drop of food coloring on top of the ice cube. Watch the cold water flow down carrying the food coloring, showing the more dense water displacing the warm water (note the circular current set up by the temperature differences). You may also hold a tissue paper parachute or umbrella shape several inches above a lit candle and see it rise due to the rising heated air, as we see in the case of a hot air balloon.<br><br>Radiation, the third way that heat is transferred, can be demonstrated by using a toaster to show the glowing wires and the bread being heated and toasted due to the rays given off. Another method is to have the students rub their hands together rapidly and notice, first, the heat due to friction, and then having them hold their hands close together, but not touching. In still air, the heat will radiate from one hand to another and they will feel the warmth of the other hand due to the transfer of heat by radiation. |

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| Classroom Procedures | Introduce the concepts of heat, thermal energy, how thermal energy flows: conduction, convection, and radiation. Solicit from the students some examples of how heated things react when heated up and cooled down. Show the video, pausing each time the presenter asks a question for student predictions or observations. Give hints when necessary. Draw some general conclusions about heat flow after the three demonstrations. Reinforce the particle nature of matter in conduction. Contrast conduction with convection and radiation with examples of heat flow in the experience of the students. |
| Materials Needed | PSI videos, glass, water, ice cube, food coloring, candle, match, tissue paper, toaster, bread |
| Science Connections | How is heat flow reduced by weatherizing homes; wearing coats, hats, gloves; using thermos bottles, coolers, pizza delivery pouches; or in the choice of material for coffee cups? Explain how any other device that encourages heat flow (fans, metals, glass or other good conductors) or slows heat flow (insulation, air space, vacuum) works.<br><br>Try these experiments:<br><br>1. Obtain containers of similar dimensions and liquid capacity—metal can, glass tumbler, plastic cup, ceramic cup, Styrofoam cup, vacuum bottle. Distribute two containers made of different material per group. Each group should have two thermometers to place in the containers. Fill each cup with hot water (as hot as it gets when run for a minute) or cold water (as cold as it gets when run for a minute). Record the initial temperature and changing temperatures under the headings of HOT and COLD every two minutes until ten readings are taken. Construct a graph (time in minutes on the horizontal axis versus temperature in degrees C on the vertical axis) of each group (hot and cold) of data and compare the line (pencil and pen, dotted and dashed) shapes and changes with other groups. Explain the results based on your understanding of thermodynamics.<br><br>2. Modify the above experiment by packing each container in a ring of crumpled newspaper (a simple strip of masking tape will hold the “insulator” in place) and place 20 sheets-cut to a diameter of 3cm greater than the rim of the cup, above and below the cups. Punch a hole in each cover for the thermometer. Record initial and changing temperatures every two minutes under HOT and COLD until ten readings are taken. Make a graph with the lines varying with dots/dashes, or with pen/pencils. Compare lines and explain the differences based on the type |

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| | of cups and the presence of insulation. Compare the differences between the two trials based on your understanding of thermodynamics.<br><br>3. Using the previous experiment, you can also observe the effect of placing a metal fork in one container, and a metal spoon in the other. Does one conduct heat from the liquid more rapidly than the other? Observe and record thermometer readings at regular intervals to demonstrate the conduction of heat through the metal utensils and eventual radiation into the air. Does the spoon conduct heat more efficiently than the fork? If so, why? |
| Additional Web Resources | U.S. Department of Energy- Energy Efficiency and Renewable energy (lesson plans and activities)<br>http://apps1.eere.energy.gov/education/lessonplans<br><br>Home Science Tools<br>http://hometrainingtools.com/articles/chocolate |

Ohio Science Standards Abbreviations:

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| ES – Earth/Space Science | LS – Life Sciences | PS – Physical Sciences |
| SI – Scientific Inquiry | ST – Science and Technology | SW – Scientific Ways of Knowing |