HEAT and TEMPERATURE

Grade Level: 6th grade
Presented by: Sally Ferrelle, Oglethorpe Academy, Savannah, GA
Length of Unit: 5 lessons

I. ABSTRACT

In the unit on heat and temperature, the students will learn how the atoms move and heat is produced. They will also observe 3 ways that heat energy can be transferred: by conduction, convection, and radiation. By participating in class activities, the students will discover how and why the direction of heat moves from a warmer area to a cooler area. Students will be introduced to formulas used to convert one temperature scale to another and how to use the specific heat of an object to find the change in energy of the object.

II. OVERVIEW

A. Concept Objectives
   1. Investigates the characteristics, movements, and measurements of heat energy.
   2. Analyzes the nature of freezing, boiling, evaporating, and condensing.
   3. Studies the relationship of matter and energy.

B. Specific content
   Content follows the *Core Knowledge Sequence* on heat and temperature, ways heat energy is transferred, and direction of heat transfer.

C. Skills
   1. Demonstrate use of thermometers.
   2. Design and conduct a scientific investigation.
   3. Use mathematics in scientific inquiry.

III. BACKGROUND KNOWLEDGE

A. Teacher Resources
   1. *Science Explorer-Motion, Forces, and Energy,* Prentice Hall, 2000, ISBN 0-13-434573-8.
   2. *Windows on Science-Physical Science, Vol. 1,* Optical Data, 1994, ISBN 1-56460-250-8.

B. Student Resources
   1. Core Knowledge Sequence – Grade 5 – Chemistry: Matter and Change.
   3. Core Knowledge Sequence – Grade 4 – Chemistry: Properties of matter.

IV. RESOURCES

Laser disc player for Windows on Science program
Fahrenheit/Celsius thermometers

V. LESSONS

Lesson One: Temperature and thermal energy (1-2 days)

A. Daily Objectives
   1. Lesson Content: Identify the three common temperature scales.
   2. Concept Objective: Contrast temperature and thermal energy.
   3. Skill Objective: Comparing and contrasting, observing by using different types of thermometers.

B. Materials:
   1. Fahrenheit/Celsius Thermometers

2. 3 bowls of water – one cold, one warm, and one at room temperature.
3. Chart paper

C. Key vocabulary:
   1. Temperature – a measure of the average kinetic energy of the individual particles in an object.
   2. Fahrenheit scale – the temperature scale on which 32 and 212 are the temperatures at which water freezes and boils.
   3. Celsius scale – the temperature scale on which zero and 100 are the temperatures at which water freezes and boils.
   4. Kelvin scale – the temperature scale on which zero is the temperature at which no more energy can be removed from matter.
   5. Absolute zero – the temperature at which no more energy can be removed from matter.
   6. Thermal energy – the total energy of the particles in an object.
   7. Degree – unit of measurement of temperature.
   8. Calorie – amount of heat required to raise the temperature of one gram of water one degree Celsius.

D. Procedures:
   1. In groups, students will brainstorm words related to temperature and come up with a definition. Responses will be shared and written down on chart paper.
   2. Students will write down vocabulary words and define terms for study.
   3. Have 3 bowls of water for each group of students. Each student will place one hand in the bowl of cold water and the other hand in the bowl of warm water. After a minute, then the student will place both hands in the bowl of room temperature water. Students will discuss in groups what they felt and why.
   4. Make paper thermometers to use for calculations and converting from Celsius to Fahrenheit and from Fahrenheit to Celsius..
   5. Use formulas to complete examples in class.
      a. From Fahrenheit to Celsius – Temperature times 5/9 – 32.
      b. From Celsius to Fahrenheit – Temperature + 32 times 9/5.
   6. Complete worksheets using calculations (Appendix A).

E. Evaluation:
   Students will compare/contrast the 3 types of temperature scales using a Venn diagram (Appendix B).

F. Standardized Test/State Test Connections:
   Review critical thinking skills by comparing and contrasting, observing, and inferring.

Lesson Two: Thermal energy and states of matter (1-2 days)

A. Daily objectives
   1. Lesson Content: Identify what causes matter to change state.
   2. Concept Objective: Relate expansion of matter to addition of thermal energy.
   3. Skill Objective: Compare/contrast evaporation and boiling. Observing, inferring, and cooperative learning.

B. Materials:
   1. Thermometers
   2. Beakers
   3. Hot plate

4. 250 ml. of ice for each group of students
5. timers
6. *Windows on Science-Physical Science, Vol.1* on heat and temperature.

C. Key vocabulary:
1. Change of state – the physical change from one state of matter to another.
2. Melting point – the temperature at which a solid changes to a liquid.
3. Freezing point – the temperature at which a substance changes from a liquid to a solid.
4. Boiling point – the temperature at which a liquid boils.
5. Vaporization – the process by which matter changes from the liquid to the gas state.
6. Evaporation – vaporization that occurs at the surface of a liquid.
7. Condensation – the change from the gaseous to the liquid form of matter.
8. Thermal expansion – the expansion of matter when it is heated.
9. Thermostat – a device that regulates temperature.
10. Thermogram – image of an object made by measuring the infrared light it gives off.

D. Procedures:
1. Have a group of students demonstrate a state of matter and the movement of molecules in that state by going to the front of the room and acting it out.
2. Students will copy and write down the terms and definitions.
3. Each group of students will design and carry out an experiment with materials to show the change in temperature as a block of ice changes from a solid to a liquid and to a gas. They will record the temperature information on a line graph and show the change of state points.
4. Share results of experiments to others.
5. Observe illustrations on laser disc program and take notes on states of matter.

E. Evaluation:
Students will write a page describing how they would measure temperature if there were no thermometers.

F. Standardized Test/State Test Connections:
Graphing skills, comparing/contrasting, observing, and drawing conclusions.

Lesson Three: Nature of heat (1-2 days)

A. Daily Objectives:
1. Lesson content: Describe how heat is related to thermal energy, identify the three forms of heat transfer.
2. Concept Objective: Relate specific heat to thermal energy.
3. Skill Objective: Inferring, communicating, interpreting data, classifying.

B. Materials:
1. Butter
2. Spoons of different materials, such as plastic, wood, silver, and other metals.
3. Glass beaker
4. Hot water
5. Balloons
6. Hot plate
7. Cold water in large container

C. Key vocabulary:
   1. Heat – the movement of thermal energy from a substance at a higher temperature to another at a lower temperature.
   2. Conduction – heat is transferred from one particle on matter to another without the movement of matter itself.
   3. Radiation – the transfer of energy by electromagnetic waves.
   4. Convection – the transfer of heat by the movement of currents within a fluid.
   5. Convection current – a current caused by the rising of heated fluid and sinking of cooled fluid.
   6. Conductor – a material that easily transfers heat between its particles.
   7. Insulator – a material that does not easily transfer heat between its particles.
   8. Specific heat – the amount of heat required to raise the temperature of one kilogram of a substance by one kelvin.

D. Procedures:
   1. Groups of students will brainstorm the word heat and write down on chart paper all words that relate to heat. These will be shared with the whole group.
   2. Students will copy and define the terms for study.
   3. Groups of students will use the materials to complete the activity in class. Place several spoons of different materials in a beaker without them touching each other. Put a small pat of butter on each utensil at the same height. Pour some hot water into the beaker and observe what happens. Students will record what happened to the butter and if it happened to each spoon. Why did this happen?
   4. Place a balloon on the lip of a beaker after pouring 100 ml. of water in it. Heat up the water on a hot plate and have students observe what happens to the balloon. (It inflates.) Next place the beaker in a larger glass of cooled water and observe the reaction of the balloon. (It deflates.) Repeat the experiment again and have the students write down their observation and explain why the balloon changed shape.

E. Evaluation:
   Students will write a paragraph that explains the difference between heat and temperature.

F. Standardized Test/State Test connections:
   Students will demonstrate observing, inferring, and critical thinking skills.

Lesson 4: Calorimeter (1 day)

A. Daily Objectives:
   1. Lesson Content: When hot water and cold water are mixed thermal energy is conserved.
   2. Concept Objective: Conservation of thermal energy.
   3. Skill Objective: Calculate the amount of heat transferred from the hot water to the cold water in the calorimeter.

B. Materials:
   See Appendix C for a list of materials

C. Key vocabulary:
   1. Calorimeter – a device that measures changes in thermal energy

D. Procedures:

1. See attached handout (Appendix C).

Lesson 5: Uses of heat (1-2 days)

A. Daily objectives:
   1. Lesson Content: Discover differences between types of combustion engines.
   1. Concept Objective: Relate thermal energy to heat engines and refrigerators.
   2. Skills Objective: Develop hypotheses, classify, and organize information.

B. Materials:
   1. Bicycle pump
   2. Deflated ball
   3. *Windows on Science-Physical Science, Vol.1* on heat and temperature.

C. Key vocabulary:
   1. Heat engine – a device that converts thermal energy into mechanical energy.
   2. Combustion – the process of burning a fuel to produce thermal energy.
   3. Internal combustion engine – an engine that burns fuel inside cylinders within the engine.
   4. External combustion engine – an engine powered by fuel burned outside the engine.

D. Procedures:
   1. Have students fill the bicycle pump and deflated ball and observe if it feels cold or warm. Inflate the ball by using the pump. Students will feel the pump and ball again to see if there are any changes in temperature. They will write down an explanation for any changes that took place.
   2. Students will copy and define the vocabulary words for study.
   3. Observe laser disc to see examples of types of engines. Students will take notes of any differences.

E. Evaluation:
   Students will compare and contrast the two types of heat engines by writing down how they are alike and different.

F. Standardized Test/State Test Connections:
   Comparing/contrasting, observing, inferring, and interpreting diagrams and photographs.

VI. CULMINATING ACTIVITY (2 days)

1. Materials per group: 2 shoeboxes, thermometer, hot water, plastic cup, plastic wrap, newspaper, styrofoam pieces, foam board, scissors, timer, cooler with ice inside.
Students will use the material to create a house that will keep the hot water warm inside the house. Both shoeboxes will have doors and windows cut into them and plastic wrap placed over the openings. One of the shoeboxes will have no insulation and the other will have any type of insulation materials secured inside it with tape. Place a thermometer and a cup of hot water inside each shoebox. The shoeboxes should be placed inside the cooler with ice and the timer started. Time each shoebox for 5 minutes, 10 minutes, and 15 minutes. Students will record the temperatures at the end of each segment and compare the two shoeboxes to see if insulation kept the hot water warm.

2. Performance-based test on the concepts covered in this unit.

VII. HANDOUTS/WORKSHEETS

Appendices A, B, C.

VIII. BIBLIOGRAPHY

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Appendix A
Fahrenheit or Celsius?

Use the formulas to complete the conversions.

Directions:

1. To convert degrees of Fahrenheit to degrees of Celsius, complete these two steps:
   a. Subtract 32 ,
   b. Multiply by 5/9.

2. Convert the following temperatures to degrees of Celsius.
   a. 32 F _____ f. 45 F _____
   b. 212 F _____ g. 80 F _____
   c. 100 F _____ h. 115 F_____
   d. 65 F _____ i. 145 F _____
   e. 12 F _____ j. 168 F _____

3. To convert degrees of Celsius to degrees of Fahrenheit, complete these two steps:
   a. Multiply by 9/5,
   b. Add 32 .

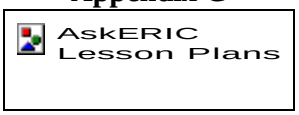
4. Convert the following degrees of Celsius to degrees of Fahrenheit.
   a. 100 C _____f. 35 C _____
   b. 0 C _____g. 20 C _____
   c. 15 C _____h. 68 C _____
   d. 40 C _____i. 25 C _____
   e. 75 C _____j. 88 C _____

Appendix B

Draw three overlapping circles that have three large areas to contrast the types of heat transfer and three areas of commonality to compare the three types and one middle area to show how all three types are alike.

Use this Venn diagram to compare and contrast the three types of heat transfer – conduction, convection, and radiation.

Appendix C



Lesson Plan #:AELP-PHY0025

Measuring Calories

An AskERIC Lesson Plan

Submitted by: Robert Willis, Riverton, Wyoming
Endorsed by: These lesson plans are the result of the work of the teachers who have attended the Columbia Education Center's Summer Workshop. CEC is a consortium of teacher from 14 western states dedicated to improving the quality of education in the rural, western, United States, and particularly the quality of math and science Education. CEC uses Big Sky Telegraph as the hub of their telecommunications network that allows the participating teachers to stay in contact with their trainers and peers that they have met at the Workshops.
Date: May 1994

Grade Level: Appropriate for grades 5-8

OVERVIEW: To help students have an understanding of energy in food by measuring the energy in calories.

OBJECTIVES: Students will be able to:

1. Explain what a calorie is.
2. Determine if one food may have more calories than another.
3. Explain how calories in food will relate to the amount of energy they will get from food.

RESOURCES/MATERIALS:

1. Ring stand or other type of hanger support.
2. aluminum can.
3. aluminum foil
4. clay
5. straight pins
6. peanuts, mini-marshmallows
7. graduated cylinder
8. Celsius thermometer
9. matches
10. water

11. paper for charts and calculations by, pencils

ACTIVITIES:

1. Use ring stand with a hook to hold can put can on hook with tab or other hanger with bottom of can about 6 cm. above ring stand base.

2. Wrap the ring stand with aluminum foil. Leave an opening to slide clay in under can.

3. Measure 100 milliliters of water and place it in the can.

4. Take the temperature of the water. Record your measurement on the worksheet. To find out how many calories are stored in the peanut, we will burn it and use the heat produced to warm some water. Then, knowing how many grams of water were warmed and how many degrees the temperature of the water rose, we can calculate the calories.

5. Place the head of a pin in a hunk of clay. Place half a shelled peanut on the point. Light the peanut with a match. As soon as it starts to burn on its own, place it under the can in the calorimeter, and allow it to burn.

   If the peanut sputters and goes out before it looks all burned up, get a new half peanut and freshwater, and start over.

   When the peanut looks all burned up and goes out, take the temperature of the water again. Record the temperature on your worksheet.

6. Calculate the Calories using the following formula.

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7.   *Amount of water used = (___milliliters = ___grams)
8.   *Temperature of water in degrees C before burning
9.   *Temperature of water in degrees C after burning
10.  *Difference in temperature
11.  *calories = (mass of water in grams) x
12.              (temp.   change in degree C)
13.
14.       Example:
15.       10 grams of water are heated 15 degree C;
16.       calories = (10 grams of water) x (15 degree C)
17.       calories = 150 calories.
18.
19.       This calculation is in small calories.  There are
20.       a thousand calories in a food Calorie, or large
21.       Calorie.  To convert calories to Calories, divide
22.       the number of small calories by 1000.
23.
24.       *food Calories or large Calories =
                                 small calories / 1000
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25. Repeat the procedure with a marshmallow.
