<u>Heat—Lesson Three</u>

Investigating Heat Radiation

Standard 6.2.3
Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred, and the change of average particle motion in various types or amounts of <u>matter</u>. Emphasize recording and evaluating date, and communicating the results of the investigation.

Scientific Practice:
- Plan and Carry out an investigation

Cross Cutting Concepts:
- Cause and Effect
- Flow of energy and matter

A. Literary Reading

Materials:
1. Literacy Reading—Heat conduction
2. Conduction Heat Transfer Examples

Directions
1. Read about ***Heat Energy***
2. Read just about ***Heat Conduction***
3. Discuss what conduction means by giving some examples. Read the examples of heat conduction
4. You may want to have a single stove unit on with water in it showing the heat transfer from the burner to the pan of water that heats the water in turn.

B. Experiments

1. "The Tale of Three Colors"—Radiation

a. Materials:
- Heat lamps
- Aluminum foil
- White construction paper
- Black construction paper
- Tape or glue
- Thermometers
- "The Tale of Three Colors" Activity Sheet

b. Directions:
1. Follow the directions on the activity sheet.
2. Answer the questions as you go.

c. Discussion:
1. Discuss the results of the experiment.
2. Communicate your ideas in your journal

2. "Make a Solar Oven"

a. Materials:

- Pizza box
- Aluminum Foil
- Scissors
- Thermometer
- Plastic Wrap
- Tape

b. Directions:

1. Cut a square hold in the top of the box a little bit smaller that the box lid itself.
2. Tape plastic wrap over the hole on the inside of the lid.
3. Line the inside of the box with tinfoil.
4. Put a thermometer in the box.
5. Put some food to cook in the box.
6. Put the solar oven in the sun.

c. Discussion

1. Discuss how the solar oven works.
2. Write your conclusions in your journal.

3. "Which Insulation Works Best" Activity

a. Materials

1. Thermometers
2. Cups of different types
3. Water
4. Heating unit
5. Pan to heat water

b. Directions:

1. Follow the directions on the activity sheet.
2. Answer the questions as you go.

c. Discussion:

1. Discuss the results of the experiment.
2. Communicate your ideas in your journal

4. "The Great Ice Cube Melt"

a. Materials

1. Plastic Cups for the ice
2. Box for the container
3. Insulation type materials: Styrofoam peanuts, packing paper, plastic of sorts, etc.

b. Directions:

1. Construct the insulator.

c. Discussion:

1. Discuss the results of the experiment.

Heat Transfer

Heat Energy

Particles that make up substances are always moving and always have energy. This energy can be transferred from one object to another by three means—*conduction, convection,* and *radiation.*

There is a difference between heat and temperature. *Heat* is the energy that the object has because the particles are moving. *Temperature* is a way of measuring heat energy. Two scales that are commonly used to measure heat are the *metric system* and the *standard system.* The metric system uses *Celsius* and the standard system uses *Fahrenheit* to measure heat. The measurement of temperature gives the average amount of energy contained in the substance.

Heat always travels from hotter to cooler objects. It may seem that when you are holding an ice cube, the ice cube is causing your hand to feel colder. However, the real physics behind this heat transference is that the feeling of coldness in your hand is caused by the heat flowing away from your hand and into the ice cube. The energy from the faster moving (hotter) particles transfer to the slower moving (colder) particles. The transfer of energy goes on until all the particles in both objects are all moving at about the same speed. When the amount of heat energy of each object is the same, both objects will have the same temperature.

Radiation

Conduction and convection need a medium to transfer heat energy. However, radiation does not. Radiation is the transfer of heat energy by electromagnetic waves such as ultraviolet waves, visible waves, infrared waves, and microwaves. Therefore, radiation does not require any certain material to go through like conduction and convection heat transfer does. It is heat that can go through anything—outer space, air, bricks, wood, soil, and metal just to name a few. Many people think that radiation radiates only downward because heat radiated from the sun appears to radiate down. Radiation heat transfer actually radiates heat out in all directions from the energy source. Examples of radiation energy sources are the sun, fire, toaster, microwaves, heat lamps, ovens, light bulbs, space heaters, and embers in a fire after the flames are gone. In other words, anything that gives off heat is radiation heat transfer. So anytime you put your hand near something that giving off heat and you can feel that heat, it is radiation heat transfer. Also, any object that has more heat energy than another object radiates heat to the cooler object. This is the reason a room heats up quickly when it is filled with hot student bodies.

These invisible waves carry energy through empty space, as well as through solids, liquids, and gases. All objects give off electromagnetic radiation, which means warm object emit more radiation than cool objects.

The heat from we receive from the Sun is radiant heat. This radiant heat travels as waves through space. Heat waves hit Earth and cause warming. Your house gets warms when the Sun's waves travel through the windows and walls. This heat gets trapped warming it up inside.

Examples of everyday radiation heat transfer are feeling the warmth of a fire while roasting marshmallows, heat going through the sides of your car or house to make it extremely hot inside, a toaster, space heater, radiator, microwave oven, and anything that you are standing next to, but not touching, where you can feel the heat from that object.

Radiation

Transfer of heat by electromagnetic waves

Toes are warmed in front of a space heater

A marshmallow turns brown when held over hot coals

The sun melts the ice formed on a frosty lawn

A sunbather gets a nasty sunburn after laying out for too long

Slices of bread turn brown in a toaster

The Tale of Three Colors

Work Sheet 1

(You can either use Work Sheet 1 or Work Sheet 2 for this activity.)

Focus Question: What difference does color make in absorbing heat?

Predict which color will be the hottest after 10 minutes under a hot lamp.

Hottest color on the 3 flat colored surfaces ____________________

Hottest color in the 3 colored envelopes ____________________

Hottest color in the 3-chambered box ____________________

Colors on 3 Flat Colored Surfaces

Flat Surface	Starting Temperature	Temperature after 5 min.	Temperature after 10 min.
Silver			
Black			
White			

Colors in the 3 Colored Envelopes

Envelope	Starting Temperature	Temperature after 5 min.	Temperature after 10 min.
Silver			
Black			
White			

Colors in the 3-Chambered Box

Chamber	Starting Temperature	Temperature after 5 min.	Temperature after 10 min.
Silver			
Black			
White			

Write the actual results of the experiment.

Hottest color on the 3 flat colored surfaces ____________________

Hottest color in the 3 colored envelopes ____________________

Hottest color in the 3-chambered box ____________________

Answer the following questions:

1. What type of heat transfer is occurring when the lamp shines on the colors?

____

____

2. Does the color of paper make a difference in the heat absorption?

____

____

3. Why was there a difference in whether the color was on a flat surface, inside an envelope, or in a box?

____

____

4. Give an example of how each result (3 examples) could be applied to real life experiences.

____

____

The Tale of Three Colors
Work Sheet 2

(You can either use Work Sheet 1 or Work Sheet 2 for this activity.)

Experiment One

1. Get a piece of black, white, and any other color construction paper. Cut out a 4" x 8" piece from each color. Put tin foil around the any other color construction paper. Put a thermometer on top of each flat paper. Read the beginning temperatures of each thermometer and record them.

   Black flat paper beginning temperature: _________

   White flat paper beginning temperature: _________

   Tin foil flat paper beginning temperature: _________

2. Put the three papers under a heat lamp. After 10 minutes read the final temperatures of each thermometer and record them. On the second line, write the temperature change.

   Black flat paper final temperature: _________ _________ (1)

   White flat paper final temperature: _________ _________ (2)

   Tin foil flat paper final temperature: _________ _________ (3)

Experiment Two

1. Get a piece of black, white, and any other color construction paper. Put tin foil around the any other color paper. Make boxes out of the three pieces of construction paper. Put a thermometer into each box. Read the beginning temperatures of each thermometer and record them.

   Black box beginning temperature: _________

   White box beginning temperature: _________

   Tin foil box beginning temperature: _________

2. Put the three boxes under a heat lamp. After 10 minutes read the final temperatures of each thermometer and record them. On the second line, write the temperature change.

   Black box final temperature: _________ ________ (4)

   White box final temperature: _________ ________ (5)

   Tin foil box final temperature: _________ ________ (6)

Experiment Three

1. Get a piece of black, white, and any other color construction paper. Put tin foil around the any other color paper. Make envelopes out of the three pieces of construction paper. Put a thermometer into each envelope. Read the beginning temperatures of each thermometer and record them.

   Black envelope beginning temperature: ________

   White envelope beginning temperature: ________

   Tin foil envelope beginning temperature: _______

2. Put the three envelopes under a heat lamp. After 10 minutes read the final temperatures of each thermometer and record them. On the second line, write the temperature change.

   Black envelope final temperature: ________ ________ (7)

   White envelope final temperature: ________ ________ (8)

   Tin foil envelope final temperature: ________ ________ (9)

Rerecord each of the temperatures change below so we can compare the three different temperatures of the three paper constructions with each other.

Black paper final temperatures

Black flat paper final temperature change: ________ (1)

Black box final temperature change: ________ (4)

Black envelope final temperature change: ________ (7)

White paper final temperatures

White paper final temperature change: ________ (2)

White box final temperature change: ________ (5)

White envelope final temperature change: ________ (8)

Tin foil final temperature

Tin foil paper final temperature change: ________ (3)

Tin foil box final temperature change: ________ (6)

Tin foil envelope final temperature change: ________ (9)

Answer the following questions:

1. What type of heat transfer is occurring when the lamp shines on the colors?

____

____

2. Does the color of paper make a difference in the heat absorption?

____

____

3. Why was there a difference in whether the color was on a flat surface, inside an envelope, or in a box?

____

____

4. Give an example of how each result (3 examples) could be applied to real life experiences.

____

____

Name ____

Making Solar Ovens

1. Materials:
   - Pizza box
   - Aluminum Foil
   - Scissors
   - Plastic Wrap
   - Tape
   - Thermometer

2. Directions:
   - Cut a square hold in the top of the box a little bit smaller that the box lid itself.
   - Tape plastic wrap over the hole on the inside of the lid.
   - Line the inside of the box with tinfoil
   - Put a thermometer in the box.
   - Put some food to cook in the box.
   - Put the solar oven in the sun until the food is cooked
   - Take a temperature reading every 5 or 10 minutes.

3. Discussion—Answer These Questions

   1. What did you notice about the temperature in the box over time?

      ____

      ____

   2. What was purpose of the plastic wrap over the hole?

      ____

      ____

   3. What was the purpose of the aluminum foil lining the box?

      ____

      ____

4. Why did the temperature do what it did?

5. What type of heat transfer was happening?

6. Give a summary of what was happening in the box to cook the food.

Which Insulation Works Best?

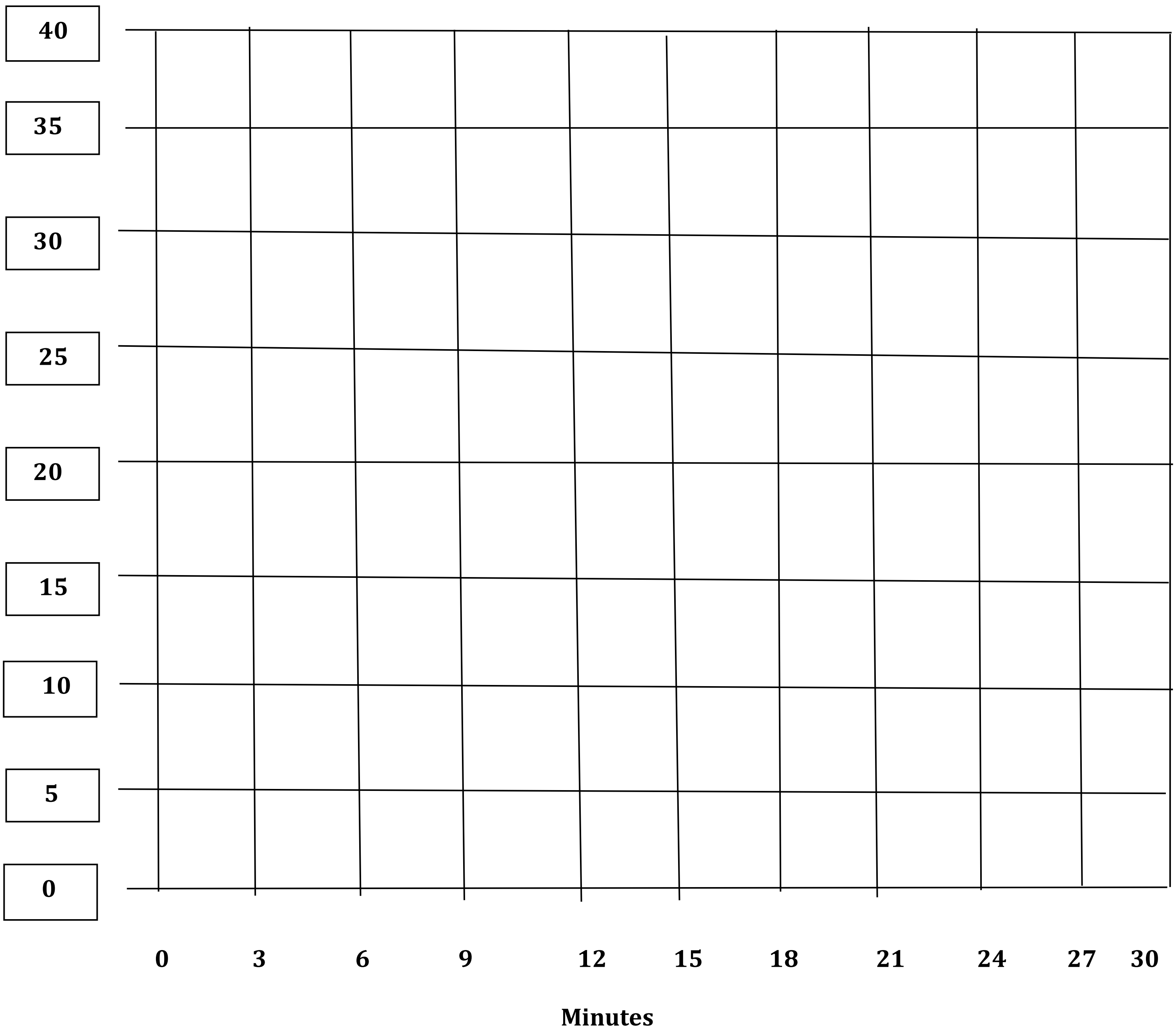
Each of you has a cup, either a tin cup and a Styrofoam cup. I have the plastic cup called the control. Each of you will get some hot water in your two cups. Write down the beginning temperature in the "beginning" row under your cups. Then every three minutes we will take the temperature of the water in the cups and write the temperature in that same column of your cup cover. Every three minutes the temperature of the water in the cups could drop, but one cup temperature could drop faster. If the temperature is dropping quickly, that cup is a "poor" insulator. If the temperature is dropping slowly it is a "good" insulator. Let's see what happens to the temperatures as we do this experiment.

Minutes	**Styrofoam Cup**		**Tin Can**		**Plastic Cup (Control)**	
	Temp	Change	Temp	Change	Temp	Change
Beginning		xxxxxxxxxx		xxxxxxxxxx		xxxxxxxxx
3 minutes						
6 minutes						
9 minutes						
12 minutes						
15 minutes						
18 minutes						
21 minutes						
24 minutes						
27 minutes						
30 minutes						

<u>Comparison Change</u>

Temperature Change

We are going to graph what happened by drawing a graph.



Name ______________________________

Does Insulating Things Work?

1. Do you see a difference between the slopes of the three lines?

____

2. What does a gentle slope mean in this experiment?

____

____

3. What does a steeper slope mean in this experiment?

____

____

4. Compare (analyze) the three slopes. Explain what happened.

____

____

____

5. Explain why this happened.

____

____

____

6. What is your conclusion?

____

____

____

The Great Ice Cube Melt

Time Needed:

- 40 to 45 minutes

Materials needed:

- Building materials for container
    - Box
    - Different insulations (newspaper, bubble wrap, plastic bags, etc.
- Ice cubes
- Plastic cup (wedding cups work best)
- Heat lamp or sunlight (optional)

Instructions:

1. Challenge: Design and build a container which will keep an ice cube from melting for 3 hours. (This can either be done at home or at school.)
2. On the assigned day:
    - Discuss the variables and controls for the test.
    - Have each student show their individual boxes explaining what materials were used etc. Have class make predictions as to which containers will be successful.
    - Place ice cubes in containers at the same time and close. Move containers to a common location, common height etc. either under a heat lamp or sunlight or away from direct heating/cooling sources. (Everyone does the same.)
    - Wait 3 hrs. , open boxes and make observations.
    - Answer the questions for discussion.

Assessment: Have a class discussion referring back to the student's original predictions. Discuss the actual results and formulate conclusions. Look at each other's insulation box and results and come up with conclusions.

Name ____

The Great Ice Cube Melt

Answer the questions to reflect on.

1. What does insulation do?

____

____

2. How does it do it as to the what answer you put in number 1?

____

____

3. Why would heat do this?

____

____

4. Which were the best insulators as you saw the results?

____

____

5. Why do you think they were the best?

____

____

6. Which were the worst insulators as you saw the results?

____

____

7. Why do you think they were the worst?

____

____

8. What are things around us that are insulated?

____

____

9. Would this work if you tried to keep things hot instead of cold? Why?

____

____

10. How would this experiment help us to understand the engineering of things that need to be kept hot or cold?

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