**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Hour: \_\_\_\_\_\_**

**Heat Capacity: How Much Heat Will it Hold?**

**Introduction/Motivation**

Today, we are talking about *thermal energy* or heat energy. Have you ever been outside on the playground on a sunny day and touched the metal of a swing set? How does it feel? It is hot? Yes! How about walking barefoot on a sunny day? Have you ever walked on the sidewalk and had to jump to the grass because the pavement was too hot for your feet? Do you think the grass and the pavement are actually different temperatures — even if it is the same temperature outside? They probably are not different temperatures at all!

Different objects require different amounts of *heat* to raise the same amount of material to the same temperature. You can notice this on a hot summer day when the ground is cool enough to walk on, but the road and sidewalk are very hot, or a metal bench is much hotter than a wooden bench. The metal bench requires less heat to make it hot than the wooden bench. When we measure this property, the quantity is called the *heat capacity* of the material. When an object absorbs heat, the thermal energy is spread among the atoms and molecules in the material. Energy makes the molecules vibrate back and forth. If the vibrations become faster, we measure it as an increase in temperature. Every material has a different heat capacity.

Another way of explaining a materials' heat capacity is to think about it as the measurement of thermal energy storage, just like temperature is the measurement of thermal energy given off. Heat capacity is how much thermal energy a material stores up and temperature is how much thermal energy a material gives off. Today, we are going to look at the heat capacity of some different materials.

Engineers use their knowledge of the thermal properties of matter to design everything from engines to satellites to houses. Engineers use a material's heat capacity to determine its usefulness for different applications. A material with a low-heat capacity (such as metals) has a greater increase in temperature from absorbing the same amount of heat as a material with a high-heat capacity (such as water). This is why materials with high-heat capacities, such as water, are used for storing thermal energy. Other materials with high-heat capacity, such as brick or concrete walls, are important to engineers designing houses that they want to stay warm in cold climates. Engineers consider heat capacity when working with any material. For example, think of all the devices and appliances in your house. If the wiring in your computer or lamp or hair dryer gets too hot, it may spark and stop working.

**Vocabulary/Definitions**

**Heat:** A form of energy associated with the motion of atoms or molecules, and capable of being transmitted through solid and fluid media by conduction, through fluid media by convection, and through empty space by radiation.

**Heat Capacity:** The amount of heat required to raise the temperature of one mole or one gram of a substance by one degree Celsius without a change of phase (from solid to liquid, or liquid to gas, etc.).

**Thermal Energy:** The energy an object has due to the motion of its particles, also called heat energy.

**Materials**

4 thermometers

2 small jars

2 beakers

Assigned Material (for testing)

**Teacher Prepared Materials**

Water (Hot Water and Ice Water)

**Procedure**

1. Divide groups into “jobs”: One student for thermometer in the material, one student read the thermometer in the water, a student for recording, a student for gathering materials/clean-up, a student for time keeper, etc.
2. Predict which material will have the highest heat capacity (store thermal energy the best), and record this on your worksheet.
3. Measure 200 ml of the assigned material using a measuring cup or jar with the 200 ml level marked.
4. Have the student testing water pour the hot water in his/her container (large jar) and place a thermometer in the container. Get water from designated area.
5. Have students testing the powdered material, sand or dirt, fill the beaker halfway (small jar), place a thermometer into the material and then finish filling their containers. The material must cover the thermometer bulb or bottom.
6. Measure and record the initial temperatures of the materials and water. Remind the recorders to document the starting temperatures on their worksheets.
7. Place the beakers/jars of material into the large container of hot water.
8. Measure and record the temperature of the material and the water bath every minute for 10 minutes. Record the starting temperature of the 200 ml beaker of water, sand, and paper, etc., and the temperature of the hot water bath at "0" minutes. Record the temperature reading of each of the thermometers every 1 (or 2) minutes in the table.
9. Have each team member pour the contents of their beaker/jar into waste containers at the appropriate station.
10. Repeat the entire activity using ice water instead of hot water.

**Data and Observations**

1. Prediction: We predict that \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ material will hold heat the longest (= best thermal energy storage).
2. Our team is measuring \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ material.
3. Do you think your material will hold the heat? Cold?

**Hot Water Cold Water**

|  |  |  |
| --- | --- | --- |
| Minute | Temperature of Material | Temperature of Water |
| 0 (Start) |  |  |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |

|  |  |  |
| --- | --- | --- |
| Minute | Temperature of Material | Temperature of Water |
| 0 (Start) |  |  |
| 1 |  |  |
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| 5 |  |  |
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Was your prediction correct? Why or why not?

**Directions: Draw a graph of your results for your material in *hot water*.**

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**Directions: Draw a graph of your results for your material in *cold water*.**

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**Conclusion (Entire Class)**

1. Which materials had the highest heat capacity? (stored heat the longest)
2. Which material had the lowest heat capacity?
3. What have you learned using these materials and heat capacity?
4. How would an engineer use this information to choose material to build a home, insulate a home, design food storage container for soup, or choose a material that you need to heat up quickly?

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