Laboratory Investigation — Name ______________________

Physics@Frisch: Form L10.2A — Date ______________ Period ____

Heat Conduction

PROBLEM

How does heat pass through different materials?

INTRODUCTION

Conduction is the transfer of heat through materials by the direct contact of matter. All materials conduct heat at some rate. Solids usually are better heat conductors than liquids, and liquids are better conductors than gases. The thermal conductivity of a material describes how well the material conducts heat. Materials with high thermal conductivity, such as copper, aluminum, and other metals, are good thermal conductors. Materials with low thermal conductivity, like fiberglass and foam, are insulators. This investigation explores how different materials conduct heat. In this investigation, you will: compare the thermal insulating or conducting properties of materials; and measure the heat flowing between two different temperatures.

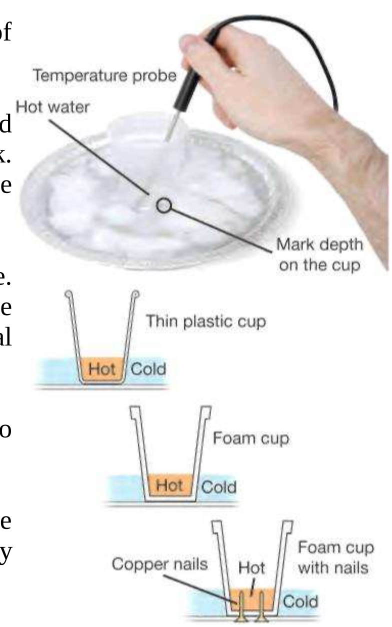
MATERIALS *(per group)*

Balance (accuracy to at least 0.1 gram); Beaker; Copper nails (4); Crushed ice; Data Collector; Foam cups (2); Hot plate; Metric ruler; Permanent marker; Ring stand; Shallow baking pan; Small pot; Temperature probe or Thermometer; Thermometer clamp; Thin plastic cup; Water

PROCEDURE

1. Heat a beaker of water to a temperature of at least 60°C. Fill a shallow baking pan with 2 centimeters of water and crushed ice.

2. Use the Data Collector in meter mode and the temperature probe to measure the temperature of the cold water bath. Record this and all other measurements in Table on the next page.



3. Measure the mass of an empty thin plastic disposable cup. Measure the depth of water in the cold pan. Mark the depth on the plastic cup with a marker. Fill the cup with hot water to the mark. Measure the mass of the cup with the water. Subtract to find the mass of the water. Enter the mass in all three rows of table on the next page since it is the same for each trial.

4. Hold the cup of hot water in the pan of cold water and swirl it gently with the temperature probe. Use the running clock at the bottom of the meter screen to measure the time it takes for the temperature to drop from 50°C to 40°C, and from 30°C to 20°C. Use the same starting and final temperatures for all variations of the experiment.

5. Repeat the same experiment except use a foam cup to hold the hot water. Use the plastic cup to transfer the new hot water to the foam cup so the volume of water stays constant.

6. Prepare another foam cup by pushing four copper nails through the bottom as shown in the diagram. Repeat the experiment again with this set up. Remember to swirl the cup constantly with the temperature probe as you are monitoring the temperature.

7. For this part of the investigation, set up the opposite circumstance. Heat will flow from the hot water in the pan to the cold water in the cup. Fill the pan with two centimeters of hot water that is at least 60°C. You may need to add hot water from time to time to keep the water temperature within 3–4 degrees of 60°C. Fill a second container with crushed ice and enough water to refill the cup several times.

8. Repeat the same three experimental variations you did in Steps 4–6, except this time the heat will flow into the cup. Measure the time it takes for the temperature of the water in the cup to go from 20°C to 30°C, and from 40°C to 50°C. Again, be sure to gently swirl the cup around the bottom of the pan to mix the water and even out the temperature. Keep the temperature probe in the cup.

9. Record the temperature of the water in the pan and the mass of water in the cup in the appropriate row with the times using the bottom part of Table below.

OBSERVATIONS

Temperature and Mass Data				
Heat flowing from cup to pan	**Cold temperature**	**Mass (g)**	**Time (s)**	
			50°C to 40°C	**30°C to 20°C**
Plastic cup				
Foam cup				
Foam cup, nails				

Heat flowing from pan to cup	**Hot temperature**	**Mass (g)**	**Time (s)**	
			20°C to 30°C	**40°C to 50°C**
Plastic cup				
Foam cup				
Foam cup, nails				

CONCLUSIONS

1. Use the concept of thermal conductivity to explain the differences between the measurements for the plastic cup, the foam cup, and the foam cup with the nails pushed through the bottom. ______________________________

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2. Compare the time it took the water in the cup to cool down from 50°C to 40°C with the time it took to cool down from 30°C to 20°C. Explain the difference using what you know about how heat flows. ______________________________

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3. The specific heat of water is 4.184 J/g°C. Use the heat equation to calculate how much energy was used to change the temperature of the water from 20°C to 30°C. Show your work.

4. How does the amount of energy used to heat the water from 20°C to 30°C compare with the amount of energy used to heat the water from 40°C to 50°C. Does this make sense. Explain. ______________________________

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