

Name: \_\_\_\_\_ Date: \_\_\_\_\_

## Student Exploration: Heat Transfer by Conduction

**Vocabulary:** conduction, convection, insulate, radiation, thermal conductor, thermal energy, thermal insulator

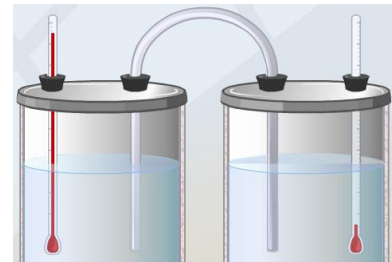
**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)

Suppose two frying pans have been left on the stove with the burners on. One of the frying pans has a metal handle and the other has a wooden handle.

1. Which handle do you think you could safely touch? \_\_\_\_\_
2. Why do you think one handle will be cooler than the other? \_\_\_\_\_  
\_\_\_\_\_

**Gizmo Warm-up**

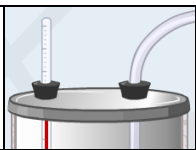
Heat, also called **thermal energy**, can be transmitted through space (**radiation**), by moving fluids (**convection**), or through direct contact. This final method, called **conduction**, is explored in the *Heat Transfer by Conduction* Gizmo™.



To begin, check that **Aluminum** is selected. Select the **BAR CHART** tab and turn on **Show numerical values**.

1. What is the initial temperature of each beaker? **Beaker A** \_\_\_\_\_ **Beaker B** \_\_\_\_\_
2. Click **Play** (▶) and observe.
  - A. What happens to the temperature of **Beaker A** over time? \_\_\_\_\_  
\_\_\_\_\_
  - B. What happens to the temperature of **Beaker B** over time? \_\_\_\_\_  
\_\_\_\_\_
3. Why do you think the temperatures of **Beaker A** and **Beaker B** changed as they did?  
\_\_\_\_\_  
\_\_\_\_\_



<b>Activity A:</b> <b>Measuring heat transfer</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Click <b>Reset</b> (↺).</li> <li>• Check that <b>Aluminum</b> is selected.</li> </ul>	
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**Question: How does the temperature difference between two containers relate to the rate of temperature change?**

1. Observe: Select the GRAPH tab and press **Play**. Wait until the temperatures of the two beakers are both close to 50 °C, and use the zoom out button (−) to see the whole graph. Sketch the graph in the space at right.

What does the graph show about the rate of temperature change over time?

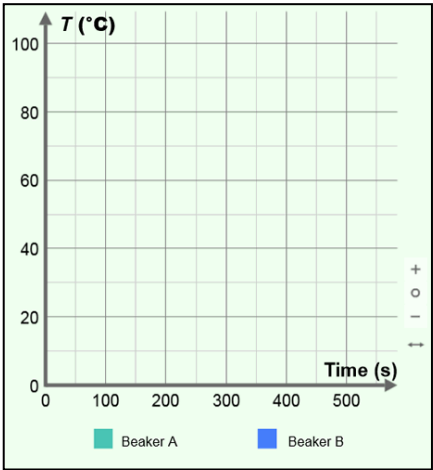
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2. Form hypothesis: How do you think the temperature difference between the beakers relates to the rate of heat transfer? \_\_\_\_\_

3. Gather data: Select the TABLE tab. Click **Reset**, and then click **Play**. Click **Pause** (⏸) every 100 seconds (does not have to be exact). Each time you click **Pause**, record the temperature of each beaker and their temperature difference in the table below. (To find the temperature difference, subtract the temperature of beaker B from that of beaker A.)

Time (s)	Beaker A temp. (°C)	Beaker B temp. (°C)	Temp. difference (°C)
0 s			
100 s			
200 s			
300 s			
400 s			
500 s			
600 s			

**(Activity A continued on next page)**

**Activity A (continued from previous page)**

4. Calculate: At each time, what is the sum of the temperatures in each beaker? \_\_\_\_\_

5. Apply: In this simulation, the beakers are perfectly **insulated**. This means that no thermal energy (heat) is lost to the outside environment. If the beakers were *not* perfectly insulated, how do you think the sum of their temperatures would change over time? Explain.

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6. Compare: Compare the temperature changes in the 0–100 second interval to the 500–600 second interval. First, record the temperature difference at the start of each interval. Then, calculate how much the temperature in each beaker changed during the interval.

Value	0–100 s interval	500–600 s interval
Temperature difference at the start of the time interval		
Change in <b>Beaker A</b> temperature		
Change in <b>Beaker B</b> temperature		

7. Analyze: How does the rate of temperature change depend on the temperature difference between the two beakers? \_\_\_\_\_

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8. Think and discuss: Why do you think the rate of temperature change does not stay constant over time? If possible, discuss your answer with your teacher and classmates.

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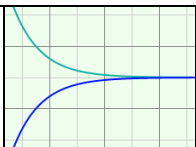
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<b>Activity B:</b> <b>Conductors and insulators</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Click <b>Reset</b>.</li> <li>• Select the <b>TABLE</b> tab.</li> </ul>	
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**Introduction:** Materials that allow heat to pass through easily are called **thermal conductors**. Materials that resist the transfer of heat are called **thermal insulators**.

**Question: Which materials are the best conductors? Which are the worst conductors?**

1. Predict: In the Gizmo, you can use aluminum, copper, steel, or glass to connect the two insulated beakers.

- A. Which material do you think will be the best thermal conductor? \_\_\_\_\_
- B. Which material do you think will be the best thermal insulator? \_\_\_\_\_

2. Gather data: With **Aluminum** selected, click **Play**. Click **Pause** after about 200 simulated seconds. Record the temperature of each beaker at 200 seconds. Next, calculate the temperature change of **Beaker A**. Repeat with each material to complete the table.

Material	Beaker A temp. at 200 seconds (°C)	Beaker B temp. at 200 seconds (°C)	Beaker A temp. change (°C)
Aluminum			
Copper			
Steel			
Glass			

3. Analyze: What does your data indicate? \_\_\_\_\_  
 \_\_\_\_\_

4. Classify: Which materials would you classify as thermal conductors, and which would you classify as an insulator? Which material was the best thermal conductor?

Thermal conductors: \_\_\_\_\_

Thermal insulator: \_\_\_\_\_ Best thermal conductor: \_\_\_\_\_

5. Apply: A good frying pan will transfer heat quickly from the stove burner to the food. Based on the results of the Gizmo, which material would be best for frying pans? \_\_\_\_\_

Why? \_\_\_\_\_

