Lava Flows

Overview:

During this lesson students will measure the speed of molasses (at two different temperatures) flowing down a slope. The viscosity of a fluid is a measure of how much a fluid resists flow. The viscosity of molasses is dependent upon temperature, just as the viscosity of a pāhoehoe lava flow is dependent upon temperature.

Objectives:

The student will:

- learn that temperature can affect the viscosity of both molasses and pāhoehoe lava;
- calculate the speed of molasses flowing down a slope and understand its similarity to the speed of pāhoehoe lava flowing down a slope; and
- graph molasses flow information.

Materials:

- Cookie sheet (1 per group)
- Wax paper
- Eye droppers (2 per group)
- Bottle of molasses at room temperature
- Stopwatch
- Crock pot or microwave (to heat molasses and water)
- Molasses Drip Grid
- Paper cup (2 per group)
- Tape
- Calculator
- Bowl of hot water
- Student Worksheet: "Lava Flows"

Answers to Student Worksheet:

Data: Chart answers will vary

Analysis:
1. Graph answers will vary
2. b) warm molasses

Conclusion: If pāhoehoe lava is heated, then the viscosity of the lava will be LOWER than the viscosity of unheated pāhoehoe lava.
Other answers will vary

Further Questions:
1. a) extremely hot pāhoehoe
2. the unheated molasses
3. the temperature of the molasses

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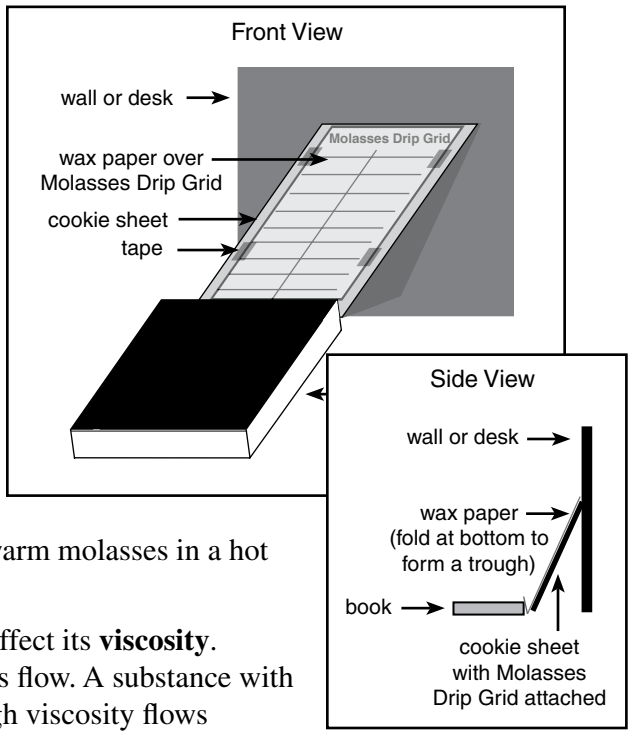
Activity Procedure:



Note: In preparation for this activity you may wish to measure how fast your students walk and run a course of 100 meters. This will introduce the concept of velocity as distance over time, and help students understand how fast they can walk or run in metric units. It also will help students relate the velocities of a pāhoehoe lava flow, an ʻaʻā flow, and a molasses flow to the velocities of their own walking and running.

1. Warm one bottle of molasses by pouring it in a beaker and heating it in a microwave. Keep the warm molasses in a hot water bath.
2. Explain that the temperature of a substance can affect its **viscosity**. Viscosity is a measure of how much a fluid resists flow. A substance with low viscosity flows quickly. A substance with high viscosity flows slowly. The viscosities of some substances, such as molasses and pāhoehoe lava, can be changed by changing the temperature of the substance.
3. Explain that students will calculate the speed at which molasses flows at different temperatures. This exercise will help them understand that pāhoehoe can flow at different speeds depending on its temperature.
4. Divide students into groups of four. Give each group a cookie sheet, 2 feet of wax paper, 2 eye droppers, 2 paper cups (one with about two tablespoons of room temperature molasses and one with about two tablespoons of warm molasses), a Molasses Drip Grid, and Scotch tape.
5. Distribute the Student Worksheets: "Lava Flows," and ask students to read the Testable Question and Background Information. Ask students how they think temperature affects the viscosity of pāhoehoe lava. Students should record their prediction in the Hypothesis section of their worksheets. Ask students to complete their experiments by following the procedure.
6. As students work, explain that it is important that the slope of the cookie sheet does not change during the experiment. Discuss experimental controls and variables.
7. After groups have completed the experiment, ask each student to write the times recorded by their Recorder in the table on their individual Student Worksheets, then use a calculator to determine the average speed of the molasses as it traveled every five centimeters. Students should write their calculations in the remaining columns of the table on their Student Worksheets.

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8. Ensure all students graph the time it takes for the two different temperatures of molasses to flow down the wax paper on the graph on their Student Worksheet: "Lava Flows." Remind students to label the increments on the y-axis of the graph.
9. All groups should discover that warm molasses flows faster than room temperature molasses. Discuss how lava behaves in the same way. Hot pāhoehoe lava flows faster than cooler pāhoehoe lava because hot pāhoehoe has a lower viscosity. Steep graphs indicate slow flows.

Note: Most pāhoehoe lava flows slower than people walk (about 1 km or .6 mph). Most ʻaʻā flows slower than people run (about 10 km or 6 mph). However, this does not mean that ʻaʻā is hotter than pāhoehoe. In fact, ʻaʻā is generally cooler than pāhoehoe, but moves faster because its flow is more voluminous. Lava flow speeds are affected by other factors than temperature, such as volume and ground slope.

	Warm Molasses X	Unheated Molasses X
5 cm		
10 cm		
15 cm		
20 cm		

Name:_____ **Student Worksheet**

Lava Flows

Testable Question:

How does temperature affect the viscosity of pāhoehoe lava?

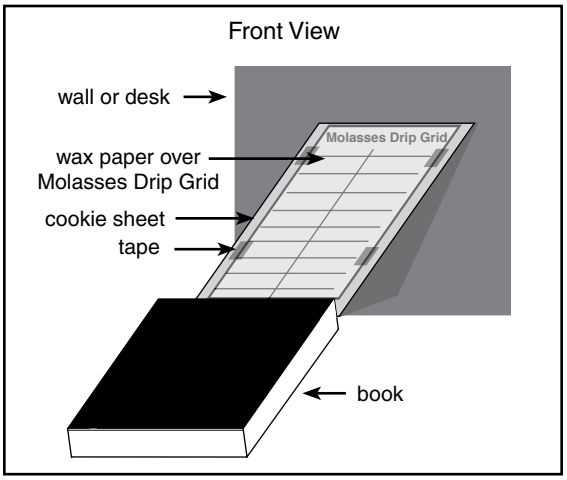
Background Information:

Viscosity is a measure of how much a fluid resists flow. A liquid with low viscosity flows quickly. A liquid with a high viscosity flows slowly. The viscosities of some substances, such as molasses and pāhoehoe lava, can be changed by changing the temperature of the substance.

Hypothesis:

During this experiment molasses will be used as a model for how temperature affects the viscosity of pāhoehoe lava. Finish your hypothesis by writing 'higher' or 'lower' in the blank below.

If pāhoehoe lava is heated, then the viscosity of the lava will be _____ than the viscosity of unheated pāhoehoe lava.



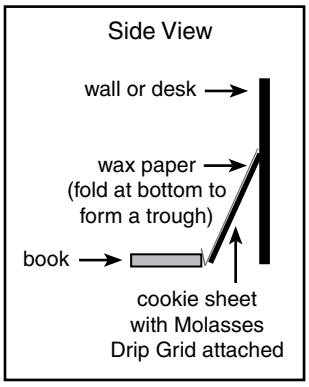
Materials:

- Cookie sheet
- Wax paper
- 2 Eye droppers
- Molasses Drip Grid
- Calculator
- Paper cup warm molasses
- Tape
- Paper cup unheated molasses
- Stopwatch

Name:_____ **Student Worksheet**

Lava Flows

Procedure:



1. Tape the Molasses Drip Grid to the cookie sheet.
2. Tape wax paper flat over the grid. If the wax paper is longer than the cookie sheet, fold the bottom of the wax paper to form a trough below the bottom of the Molasses Drip Grid.
3. Prop the cookie sheet against the leg of a desk or a wall so that it sits at a steep slope (between 45 and 70 degrees). Use a textbook to hold the cookie sheet in place.
4. Designate a Slope Monitor, a Materials Manager, a Timekeeper and a Recorder within your group.
5. Slope Monitor: Ensure the slope of the cookie sheet does not change during the experiment.
6. Materials Manager: Fill one eyedropper with warm molasses (from the warm molasses cup) and put 10 drops onto the "x" at the top of the Warm Molasses column of the grid.
7. Timekeeper: Start the timer when the first drop of molasses hits the paper, then report to the Recorder how long it takes the warm molasses to reach each of the following: the 5 cm line, the 10 cm line, the 15 cm line, and the 20 cm line.
8. Recorder: Write these times (to the nearest second) on the chart in the "Data" section of your worksheet. Write clearly so that the rest of your group can transfer the data to their own charts after the experiment is complete.
9. Repeat steps 5-8 using the unheated molasses.

Data:

Complete the chart for both unheated and warm molasses. Remember that the viscosity of molasses is dependent on temperature, just as the viscosity of pāhoehoe lava is dependent on temperature.

	Warm Molasses		Unheated Molasses	
Distance	Time	Average Speed (distance ÷ time = speed)	Time	Average Speed (distance ÷ time = speed)
5 cm				
10 cm				
15 cm				
20 cm				

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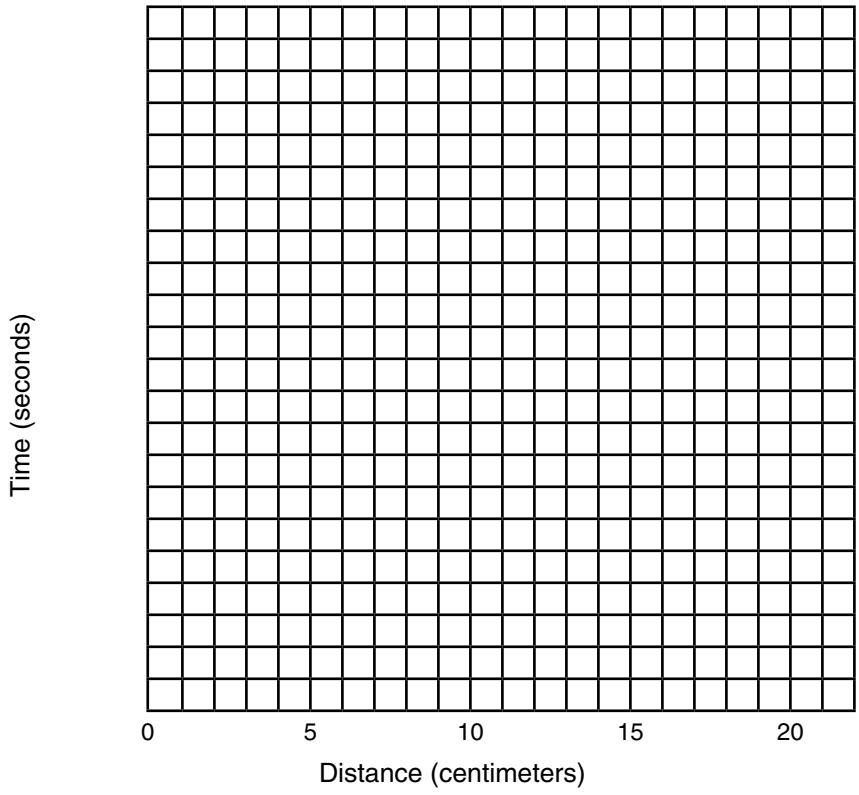
Analysis of Data:

1. Use the information from your chart to plot time and distance of the warm molasses and the unheated molasses on the graph. Be sure to number the y-axis.



2. Which molasses flowed faster?
   a) unheated molasses
   b) warm molasses
   c) neither

Name:_____ **Student Worksheet**

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Conclusion:

If pāhoehoe lava is heated, then the viscosity of the lava will be _____ than the viscosity of unheated pāhoehoe lava.

Was your hypothesis proved or disproved? Explain your answer.

_____

_____

_____

_____

Further Questions:

1. From the list below, choose the lava with the lowest viscosity that flows the fastest.
   a) extremely hot pāhoehoe
   b) very hot pāhoehoe
   c) hot pāhoehoe

2. What is the control in this experiment?_____

3. What is the variable in this experiment?_____

