MICROGRAVITY

Candle Flames

Objective:

- To investigate the effect of gravity on the burning rate of candles.

Science Standards:

Science as Inquiry
Physical Science
- properties of objects & materials
Unifying Concepts & Processes
Change, Constancy, & Measurement

Science Process Skills:

Observing
Communicating
Measuring
Collecting Data
Inferring
Hypothesizing
Predicting
Investigating

Mathematics Standards:

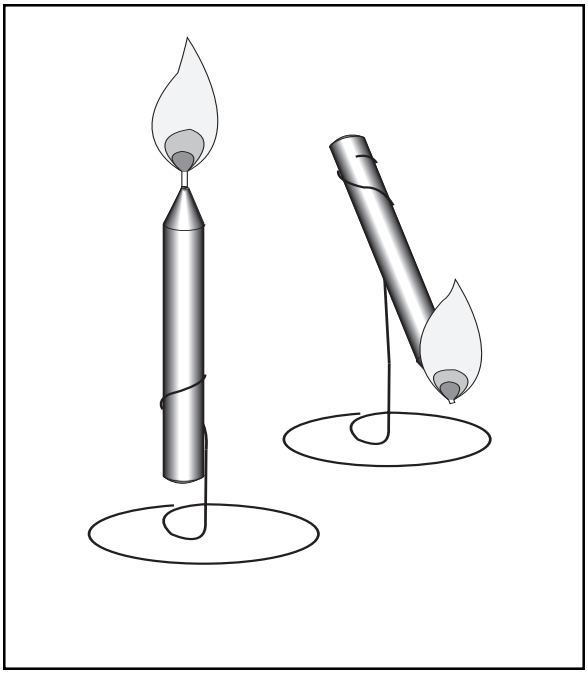
Measurement

Activity Management:

This activity serves as an introduction to the candle drop activity that follows. In both activities, students are organized into cooperative learning groups of three. It may be useful to keep the same groups together for both activities.

The objective of this activity is to observe candle flame properties and prepare students to make observations of candle flames in microgravity where observing conditions are more difficult. Before letting students start the activity, conduct a discussion on the different observations they can make. Make a list of terms that can be used to describe flame shape, size, color, and brightness.

At the end of the experirnent, student groups are asked to write a hypothesis to explain the differences observed in the burning of the two candles. It may be helpful to discuss hypothesis



The burning rate and other properties of candle flames are investigated.

Materials and Tools

Birthday candles (2 per group)
Matches
Balance beam scale (0.1 gm or greater sensitivity)
Clock with second hand or stopwatch
Wire cutter/pliers
Wire (florist or craft)
20 cm square of aluminum foil
Eye protection

writing before they get to that part. The hypotheses should relate to gravity-induced effects. In the case of candle 2, the wax of the candle is above the flame. Convection currents (a gravity-driven phenomenon) deliver lots of heat to the candle which causes more rapid melting than occurs with candle 1. Much of that wax quickly drips off the candle (gravity pulls the wax off) so more wick is exposed and the candle burns faster.

The wire used in this activity is a lightweight wire of the kind used by florists and in craft work. You can find this wire in craft and hardware stores. Do not use wire with plastic insulation. The flame of the candle tipped at an angle of 70 degrees may reach the wire and begin burning the insulation. Each group will need two wires about 20 centimeters long. Precut the aluminum foil into 20 centimeter squares. One square is needed for each group.

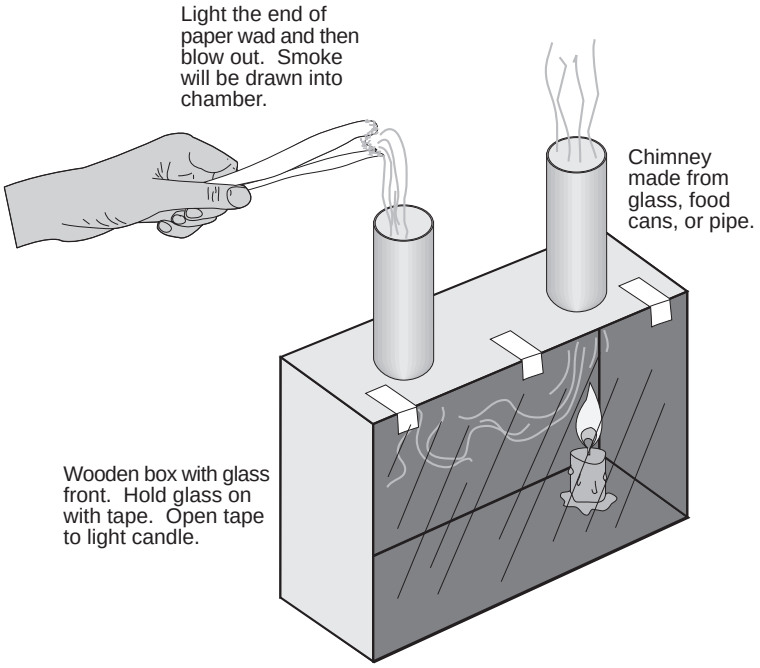
Provide each group with one set of student sheets. Save the student reader for use after the activity has been completed.

Assessment:

Discuss student observations of the candle burning and their hypotheses. Collect the student work sheets for assessment.

Extensions:

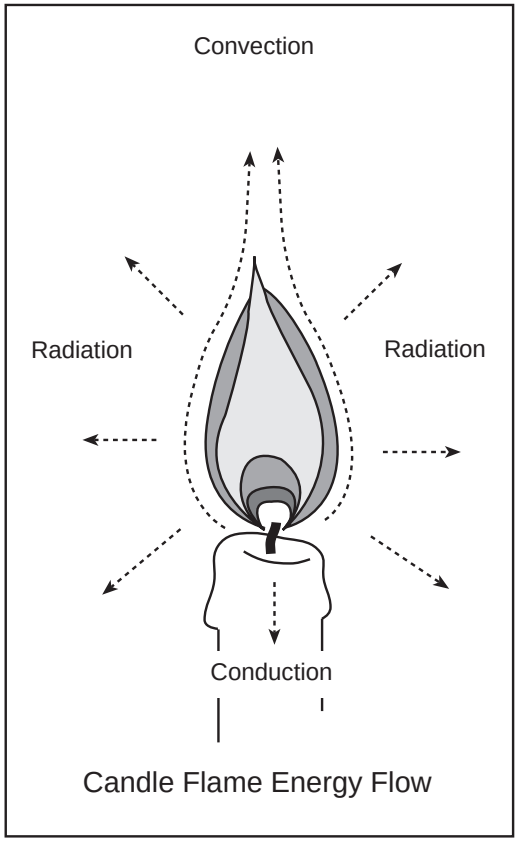
1. Burn a horizontally held candle for one minute. Weigh the candle before lighting it. As it burns, record the colors, size, and shape of the candle flame. Weigh the candle again and calculate how much mass was lost.
2. Repeat the above experiments with the candles inside a large sealed jar. Let the candles burn to completion. Record the time it takes each candle to burn. Determine how and why the burning rate changed.
3. Burn two candles which are close together. Record the burning rate and weigh the candles. Is the burning rate faster or slower than each candle alone? Why?
4. Investigate convection currents with a convection current demonstration apparatus that is obtained from science supply catalogs, or construct the apparatus as shown below.
5. Obtain a copy of Michael Faraday's book, *The Chemical History of a Candle*, and do the experiments described. (See reference list.)



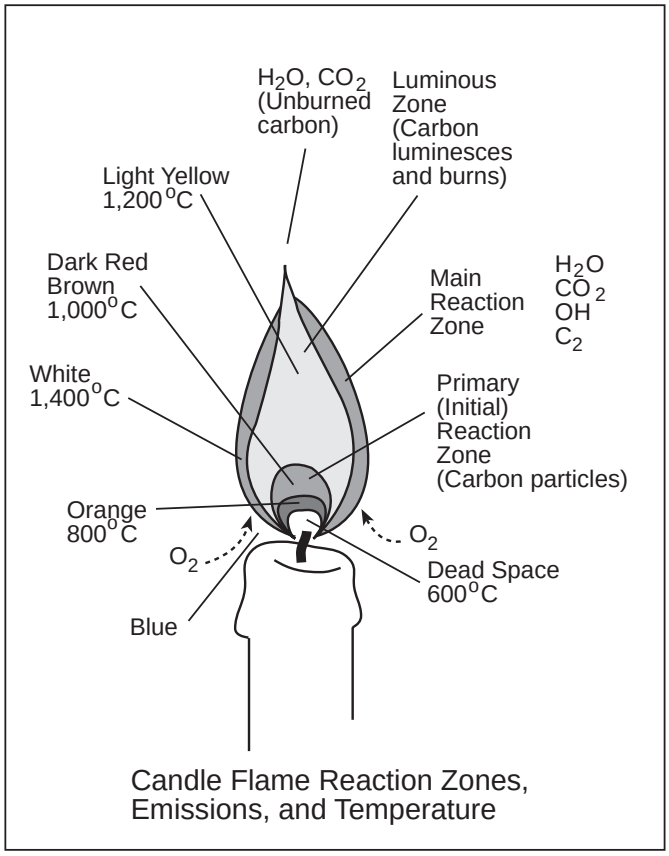
Candle Flames

Candles are useful for illustrating the complicated physical and chemical processes that take place during combustion. The candle flame surface itself is the place where fuel (wax vapor) and oxygen mix and burn at high temperatures, radiating heat and light. Heat from the flame is conducted down the wick and melts the wax at the wick base. The liquid wax rises up the wick because of capillary action. As the liquid wax nears the flame, the flame's heat causes it to vaporize. The vapors are drawn into the flame where they ignite. The heat produced melts more wax, and so on.

Fresh oxygen from the surrounding air is drawn into the flame primarily because of convection currents that are created by the released heat. Hot gases produced during burning are less dense than the cooler surrounding air. They rise upward and, in doing so, draw the surrounding air, containing fresh oxygen, into the flame. Solid particles of soot, that form in the region between the wick and flame, are also carried upward by the convection currents. They ignite and form the bright yellow tip of the flame. The upward flow of hot gases causes the flame to stretch out in a teardrop shape.



Candle Flame Energy Flow



Candle Flame Reaction Zones, Emissions, and Temperature

Candle flame diagrams adapted from "The Science of Flames" poster, National Energy Foundation, Salt Lake City, UT.

Candle Flames

Candle Flame Research Team Members:

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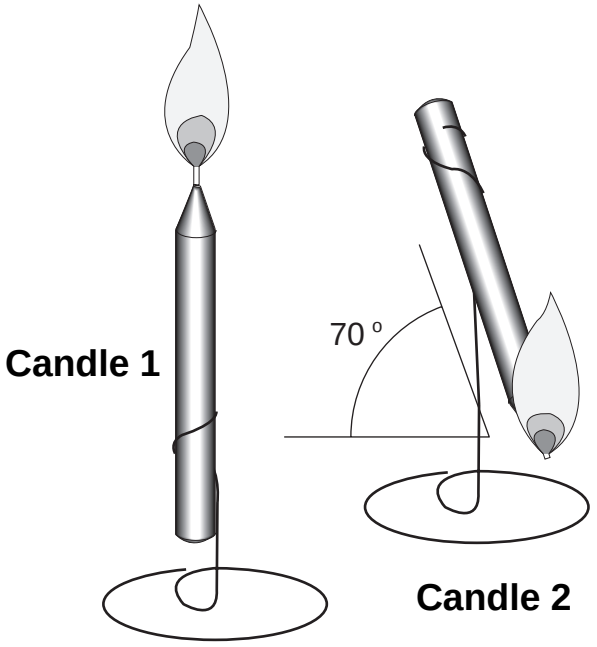
Procedure:

1. Make a wire stand for each candle so that it looks like the picture below.

2. Weigh each candle by standing it on a balance beam scale and recording its weight in grams on the chart on the next page.

3. Put on eye protection.



4. Place candle 1 on the aluminum square. Light the candle and let it burn for 1 minute. While it is burning, observe what is happening and write your observations below.

_____

_____

_____

_____

Draw a life-size picture of the candle flame.

Weigh candle 1 again and record its mass in the chart.

5. Place candle 2 on the aluminum square. Light the candle and let it burn for 1 minute. While it is burning, observe what is happening and write your observations below.

Draw a life-size picture of the candle flame.

Weigh candle 2 again and record its mass in the table.

Calculate the difference in mass for each candle and enter your answers in the table.

Candle Mass Table

	1	2
Before burning mass		
After burning mass		
Difference		

Summarize your observations below.

Write a hypothesis for how you think a candle will burn in microgravity.