Discovery Future Engineers and Scientists in Training

Human Exploration and Development of Space

Microgravity

— Surface Tension Driven Flows

Background

If you have ever looked closely at drops of water, you know that drops try to form spherical shapes. Because of gravity's pull, drops that cling to an eye dropper, for example, are stretched out. However, when the drops fall they become spherical. The shape any liquid assumes when it is in contact with another liquid or a gas is controlled by surface tension forces at the place where they meet. Like everything else, water is made up of molecules which attract each other. In the middle of a drop of water, molecules attract each other in all directions. On the surface of the drop, however, the water molecules are more attracted to the water molecules inside the drop than they are to the air molecules surrounding the drop. The water drop in air tries to pull itself into the shape that results in the least contact between air molecules and water molecules. This shape is a sphere.

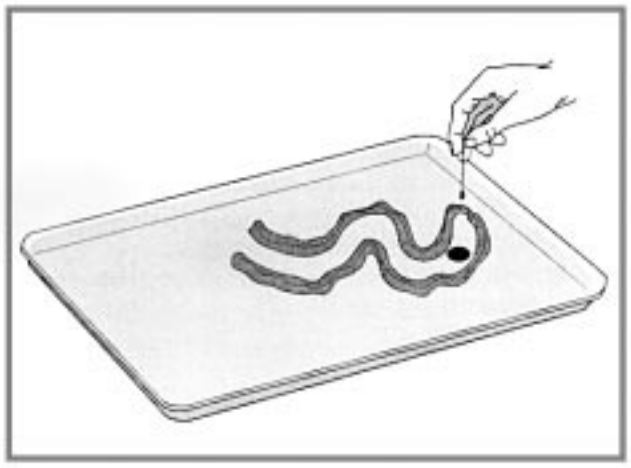
The molecules on the surface of a liquid behave like an elastic sheet. You can easily see this by floating a metal paper clip on the surface of a glass of water. Gently lower the paper clip to the water surface with a pair of tweezers. Even though the paper clip is more dense than the water, the surface tension, where the water and air meet, supports the clip. Look at the water near the paper clip and you will see that it is depressed slightly as if the water were covered by a thin sheet of rubber.

The addition of a surfactant, such as liquid soap, to water reduces its surface tension. Water molecules do not bond as strongly with soap molecules as they do with themselves. This is how soap helps you clean. The surfactant effect of liquid soap also acts on oils, helping them to break their attraction to glasses and plates. In the case of the glass of water with the floating paper clip, the bonding force that enables the molecules to behave like an elastic membrane is weakened by the addition of soap: the surface tension is greatly reduced and the paper clip quickly sinks. The surface tension can also be disrupted by outside forces like those caused by tapping the glass.

Activity

This activity demonstrates how surface tension changes can cause fluids to flow. A drop of food coloring is put near the closed end of a water-filled maze and then a surfactant is added.

Materials:
- styrofoam plate
- clay
- ruler
- water
- container to hold water
- food coloring
- toothpick
- liquid soap



1. Get a clean styrofoam plate and a piece of clay. Roll clay into 1-2 centimeter diameter "worms."

2. Lay the worms out on the plate to make a narrow valley, about 3-4 centimeters wide, that is closed on one end. Squeeze the worms so that they stick to the plate and form thin walls.

3. Add water to the plate until it almost reaches the tops of the maze walls. Let the water settle.

4. Add a drop of food coloring to the maze near the

closed end. Drop the coloring from a height of about 5 centimeters so that some of the food coloring spreads out on the surface while the rest sinks to the bottom.

5. Dip a toothpick in the liquid soap and touch the end of the toothpick to the water between the end of the maze and the food coloring. Watch what happens.

When you add the liquid soap to the water in the experiment, the surface tension is weakened in one place. The water on the surface immediately begins spreading away from the site of the soap. The clay walls channel the flow in one direction.

Watch what happens to the water at the bottom of the tray as well. To make up for the water moving away from the site where the soap was added, a second water current forms in the opposite direction along the bottom of the plate.

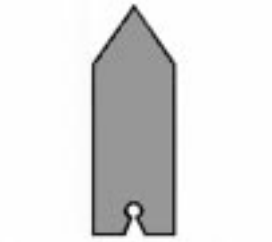
You can try this at home using different mazes and see how the width of your path affects your results. If you want to repeat the experiment, however, it is important to rinse all soap off of the plate and the clay. Any soap present at the beginning of the experiment will have already affected the surface tension.

Try This At Home!

Here are a couple of other experiments you can do at home to see more effects of surface tension.

Shake black pepper into a glass of water. Because of surface tension, the pepper will float. When a drop of soap is added to the water, the pepper will sink. This same effect can be seen from a different perspective by putting water in a petri disk and adding pepper and then soap. The pepper will be driven to the sides of the dish where particles will start sinking.

Make a surface tension-propelled paper boat by tracing and cutting out a small piece of paper in the shape shown here and floating it on clean water. Touch a small amount of liquid soap to the water in the hole at the back of the boat.



Surface Tension Paper Boat
(actual size)

The NASA Lewis Research Center Connection

On Earth, studying surface tension in the midst of gravity-related phenomena is like trying to listen to a whisper during a rock concert. In microgravity, gravity-related forces are reduced and surface tension flows become very important and easier to study. Understanding surface tension better could lead to new techniques for handling fluids that either reduce surface tension's influence or take advantage of it. In the Microgravity Science Division at NASA Lewis Research Center, many different aspects of fluid physics and fluid transport phenomena are studied, including surface tension driven flows.

Learn More by Using the World Wide Web

Visit the Microgravity Fluids Physics Website at NASA Lewis Research Center:
http://zeta.lerc.nasa.gov/6712/home6712.htm

Visit the Microgravity Science Division Educational Page:
http://zeta.lerc.nasa.gov/new/school.htm

Visit the National Center for Microgravity Research on Fluids and Combustion K-12 Educational Programs page:
http://www.ncmr.org/education.html

More information about NASA Microgravity Research Program is available at:
http://microgravity.msfc.nasa.gov/

More information about NASA Lewis Research Center is available at:
http://www.lerc.nasa.gov/

The Microgravity teacher's guide for grades 5-12 can be accessed at:
http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Microgravity/

This activity is adapted from "Surface Tension-Driven Flows," *Microgravity—A Teacher's Guide with Activities in Science, Mathematics, and Technology,* NASA EG-1997-08-110-HQ.