Gravity-Driven Fluid Flow

Objective:

- To study gravity-driven fluid flow that is caused by differences in solution density.

Science Standards:

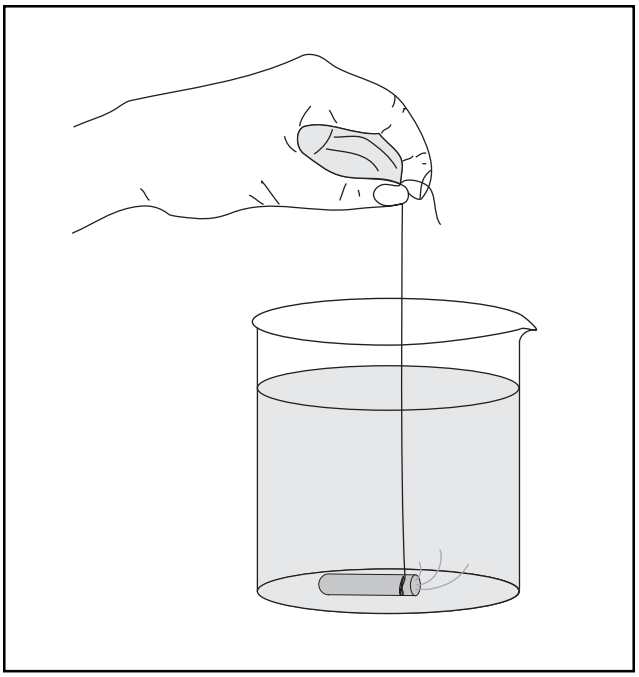
Science as Inquiry
Physical Science
- position and motion of objects
- properties of Objects and Materials
Unifying Concepts and Processes
Change, Constancy, & Measurement
Science and Technology
- abilities of technological design

Science Process Skills:

Observing
Communicating
Collecting Data
Inferring
Hypothesizing
Interpreting Data
Controlling Variabies
I nvestigating

Activity Management:

In this activity, students combine liquids of different densities to observe the fluid flow caused by gravity-driven buoyancy and settling. The activity is best done in student groups of two or three. It can also be done as a demonstration for the entire class. In this case, obtain an overhead projector and place beakers on the lighted stage. The light from below will illuminate the contents of the jars to make them easily visible from across the room. To reduce distraction, cover the projector lens to prevent blurry images from falling on the wall or screen behind. Caution: Be careful not to spill liquid on the projector.



Water of different densities is mixed to produce gravity-driven fluid flow.

Materials and Tools

2 large (500 ml) glass beakers or tall drinking glasses
2 small (5 to 10 ml) glass vials
Thread
Food coloring
Salt
Spoon or stirring rod
Measuring cup (1/4 cup)
Water
Paper towels

If using this as an activity, provide each student group with a set of materials. Salt canisters, food coloring dispensers, and measuring cups can be shared among groups. The materials list calls for glass beakers or tall drinking glasses. Other containers can be substituted such as mason jars or plastic jars like those in which peanut butter is sold.

The vials are available from school science supply catalogs for a few dollars per dozen. Choose glass vials with screw tops and a capacity of 3 to 4 ml. Small cologne sample bottles can be substituted for the vials. It is important that the vials or bottles are not too large because the process of lowering large containers into the beakers can stir up the water too much. It is recommended you tie the string around the neck of the vial yourself to make sure there is no slippage.

The student instructions ask the students to conduct three different experiments. In the first, the effects of saltwater and freshwater are investigated. In the second, the effects of warm and cold water are investigated. The third experiment is an opportunity for students to select their own materials. They might try mixing oil and vinegar, sugar and saltwater, or oil and water. It may be necessary for the third experiment to be conducted on another day while the new materials are collected.

Give each student group at least one set of instructions and two data sheets. Save the student reader for use after the experiment.

Assessment:

Discuss the experiment results to determine whether the students understand the concepts of buoyancy and sedimentation. Collect the student pages for assessment of the activity.

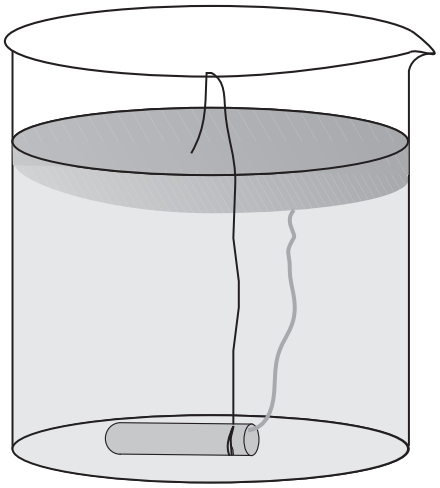
Extensions:

1. How could this experiment be conducted if it were not possible to use food coloring for a marker? (In experiments where the density of the two fluids is very close, the addition of food coloring to one fluid could alter the results.)
2. Design an apparatus that can be used to combine different fluids for experiments on the future International Space Station.
3. Design an experiment apparatus that would permit the user to control the buoyancy and sedimentation rates in the beakers.
4. Design an experiment to measure the gravity-driven effects on different fluids in which the fluids are actually gases.

Gravity-Driven Fluid Flow

Gravity is an important force at work in the movement of fluids. Fluids can be liquids or gases. The important thing about fluids is they can flow from place to place and can take the shape of the container they are in.

When you pour a liquid from one container into another, gravity is the driving force that accomplishes the transfer. Gravity also affects fluids "at rest" in a container. Add a small amount of heat to the bottom of the container and the fluid at the bottom begins to rise. The heated fluid expands slightly and becomes less dense. In other words, the fluid becomes buoyant. Cooler fluid near the top of the container is more dense and falls or sinks to the bottom.



Dyed freshwater in saltwater beaker

Many crystals grow in solutions of different compounds. For example, crystals of salt grow in concentrated solutions of salt dissolved in water. In the crystal growth process, the ions that make up the salt come out of solution and are deposited on the crystal to make it larger. When this happens, the solution that held the molecule becomes a little less salty than it was a moment ago. Consequently, the density of the solution is a little bit less than it was. This, in turn, causes a fluid flow in the solution. The slightly less salty solution is buoyant and rises to the top of the container while saltier, or more dense, solution moves in to take its place.

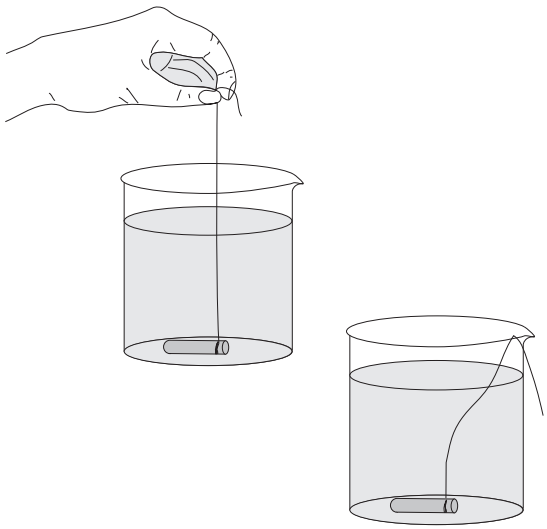
Scientists are interested in gravity-driven fluid flows because they have learned that these flows, when occurring during the growth of crystals, can create subtle changes in the finished crystals. Flaws, called defects, are produced that can alter the way those crystals perform in various applications. Crystals are used in many electronic applications, such as in computers and lasers.

To learn how to grow improved crystals on Earth, scientists have been growing crystals in the microgravity environment of Earth orbit. Microgravity virtually eliminates gravity-driven fluid flows and often produces crystals of superior quality to those grown on Earth. One of the major areas of materials science research on the International Space Station will involve crystal growth.

Gravity-Driven Fluid Flow

Procedure

1. Fill the first beaker with freshwater and set it on the lab surface. Also fill the second beaker with freshwater. Into the second beaker add approximately 50 to 100 grams of salt. Stir the water until the salt is dissolved.
2. Dip the first small glass vial into the beaker with freshwater. Fill it nearly to the top. Add a couple of drops of food coloring to the water in the vial. Close the top of the vial with your thumb and shake the water until the food coloring is mixed throughout. Place this vial next to the saltwater beaker.
3. Partially fill a second vial with salty water and food coloring. After mixing, place it in front of the beaker filled with freshwater.
4. Wait a few minutes until the water in the two beakers is still. Gently lift one of the vials by the string and slowly lower it into the beaker next to it. Let the vial rest on its side on the bottom of the beaker and drape the string over the side as shown in the pictures. Answer the questions on the data sheets and sketch what you observed in the diagrams.
5. Place the second vial in the other beaker as before. Make your observations, sketch what you observed, and answer the questions about the data.



Second Experiment Procedure:

1. Empty the two beakers and rinse them thoroughly.
2. Fill one beaker with cold water and the other with warm water.
3. Repeat steps 2 through 5 in the previous experiments.

Original Experiment:

1. On a blank sheet of paper, write a proposal for an experiment of your own design that uses different materials in the beakers. Include in your proposal an experiment hypothesis, a materials list, and the steps you will follow to conduct your experiment and collect data. Submit your experiment to your teacher for review.

2. If your experiment is accepted for testing,
   - gather your materials
   - conduct the experiment
   - submit a report summarizing your observations and conclusions

Gravity-Driven Fluid Flow
Data Sheet

Research Team Members:

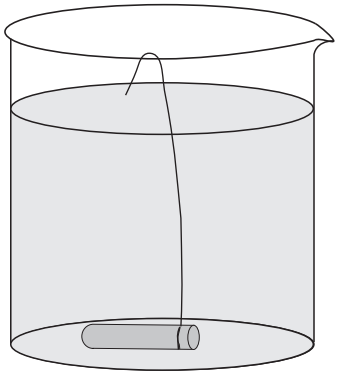
_____

_____

_____

Beaker and Vial:

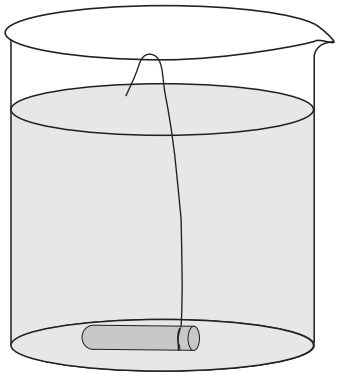
1. Water in beaker (check one)
   Fresh _____
   Salty _____
2. Water in vial (check one)
   Fresh _____
   Salty _____
3. Describe and explain what happened



Sketch what happened.

Beaker and Vial:

1. Water in beaker (check one)
   Fresh _____
   Salty _____
2. Water in vial (check one)
   Fresh _____
   Salty _____
3. Describe and explain what happened



Sketch what happened.