Andrews University
PHYSICS ENTERPRISES

Density Paradox Set

Activity Guide

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Designed by

TRANSPARENT DEVICES LLC
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Andrews University
PHYSICS ENTERPRISES

Introduction

Description

This set consists of two cylindrical solid objects with attached hooks. We have all learned that an object will float if its density is less than the density of the liquid and sink if its density is greater. Will these objects float or sink?

When the objects are dropped into a beaker of water, they immediately sink. Then, a short time later, they rise to the surface and float. Removed and dropped into another beaker, they float, and then a short time later, they sink!

Students are challenged to deduce the cause of this strange behavior.

Care and Use

The hooks in each cylinder are included as extra mass to offset the buoyancy. Without the hooks, the cylinder will always float. These hooks are installed in such a way that they are very difficult to remove. However, if someone manages to pull out a hook, you can reinsert it as follows: Place the cylinder in a pot of hot (but not boiling) water. The water should be hotter than necessary for the demonstration. After a few minutes, the plastic will expand and soften sufficiently for the hook to be re-inserted. Blow across the hole before inserting the hook to avoid trapping water.

Safety

Please teach and expect safe behavior in your classroom and lab. Safety considerations call for supervision of students at all times: safety eyewear, no horseplay, immediate reporting to the instructor of accidents or breakage, among others.

This set contains small objects and thus is not suitable for use with young children. This product is not a toy. It is for educational and laboratory use only. It is not intended for use by students age 12 years and under without competent adult supervision.

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Demonstration

Teacher Instructions

Equipment

- 1 or 2 Density Paradox Cylinders (included)
- 2 Beakers
- Hot Tap Water (recommended 40°C or warmer)
- Cold Tap Water (recommended 20°C or colder)
- Liquid Dish Soap
- Long Hook or Thread (optional—to remove cylinder from the water)

Setup

1. Fill one beaker with cold water (10-20°C). The colder you get it, the better. If possible, place the beaker in the refrigerator or melt ice into it ahead of time.

2. Fill the second beaker with hot water (40-50°C). Very hot tap water works fine for the demonstration. You do not need to heat water on the stove. The water will cool quickly after dispensing it, so it is best to fill the container right before the demonstration.

3. Add a drop or two of liquid dish soap to the cold water just before the demonstration. This will minimize the effects of surface tension that may prevent the cylinder from sinking.

Demonstration

1. Place the density cylinder in the hot water. It should sink at first, but after a minute or two, it will slowly rise to the surface. (The warmer the water, the faster this will happen.)

   Tip: The cylinder may get stuck to the side of the beaker and take longer to rise. Move the cylinder away from the walls to avoid this.

2. Remove the cylinder from the hot water and drop it into the cold water. The cylinder will float at first, but after a minute or two, it will sink.

   Tip: If the cylinder does not sink as fast as expected, there may be bubbles clinging to its surface. Dislodge the bubbles to help it sink.
   If the cylinder floats until pushed below the surface, surface tension is holding it up. Add another drop or two of dish soap to break the surface tension and allow the cylinder to sink.

Discussion

Discuss with the class—use the following prompts and/or worksheet (next page) to explain what happened.

What do you think is going on here?

The cylinder sinks and then floats or floats and then sinks. What would cause this? Allow students to speculate.

The first beaker contained hot tap water, while the second held icy cold water. Cold water is denser than hot water. Does this explain the objects' behavior?

This is only a partial explanation. The behavior of the cylinders suggests that they must have a density near that of water. Their density is greater than hot water, so they sink in hot water, and their density is less than cold water, so they float in cold water—at least at first.

Why does their behavior change after a while? Does the temperature affect the object?

Dropped into hot water, the objects get hot. Dropped into cold water, the objects get cold. Does their density change as a result? Most solids expand when heated. Does their mass also change? Why or why not? What happens to the density of a solid when it is heated? What happens to a solid when it is chilled?

For most solid substances, density changes very little with temperature changes—much less than is the case for liquids. The plastic in these objects is an exception. It expands or contracts much more than most solids as a result of temperature changes, and its density changes even more than water.

When the object is dropped into hot water, it sinks because it is denser than the hot water. Then with time, it heats up, its density becomes less than the water, and it floats. Similarly, when the hot cylinder is placed in cold water, it floats until it has cooled and contracted enough that it's density is greater than the water, and it sinks.

Activity

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