Density Layering Demonstration

Purpose: To demonstrate density layering of common fluids due to compositional differences that is analogous to layering of different salinity ocean water bodies.

Materials:
500- ml graduated cylinder
200-ml beaker
Pint, cranberry juice
Pint, orange juice (no pulp)
Pint, soda water
Blue food coloring
Small paper cups for everyone
Wide-mouth bottle or pitcher

Procedure:
1. Pour 150-ml of cranberry juice into the graduated cylinder.
It is important that all the liquids are the same temperature.
2. Tilt the graduated cylinder to 20 degrees from the horizontal and **extremely slowly** pour 150-ml of orange juice out of the beaker (after filling the beaker from the container of OJ) down the inner wall of the cylinder. If you pour very slowly, there will be a distinct density separation, in other words the OJ will stay on top of the cranberry juice.
3. Rinse the beaker, then repeat step 2 with 150-ml of soda water colored with the food coloring.
4. After a discussion of the observed fluid behavior (see below), decant the solution into the pitcher, distribute paper cups to all who are willing, and imbibe a fruit cocktail in class!

Discussion: Though the solution looks atrocious, it's pretty tasty and this is that rare instance in which students are encouraged to drink the experiment! The cranberry juice pigment and sugar content must be denser than that of the orange juice solids. The soda water is least dense not only because of sugar deficiency, but also due to its CO_2 gas content (the carbonation). By jiggling the cylinder, one can notice an undulating wave between the fluid surfaces. This is an **internal wave.** The displacement here is greater than the jiggling of the upper liquid surface exposed to the air.
As an extension, take a plug and press down on top of the solution. Notice the ring of orange juice that is expelled up into the cranberry juice.

Source: Adapted from pg .134 in Benoit Cushman-Roisin, 1994, Introduction to Geophysical Fluid Dynamics, Prentice-Hall, Englewood Cliffs, N.J., 320 pp.

Background: Density is defined as mass per unit volume, or grams per cubic centimeter in the metric system. In fluid systems, one fluid floats on top of another if it has a density that is less than the other. The downward gravitational force of the upper layer is less than the upward buoyant force of the underlying fluid. Density differences can be caused by temperature, compositional or pressure differences. In this experiment, the differences are based primarily on composition of the fluid. Even though all layers are fluids, they do not mix rapidly, if handled gently, and will stay separate for a class period or more. Masses of subtly distinctive (having different temperatures or salinities) ocean water can persist for months and over hundreds of kilometers distance. With these properties, scientists can identify and track water masses, thus learning about the speed and path of various water masses around the world.