Salt Water Hazard

Kitchen Table Demonstration

The Rundown

Time: 15 minutes
Content: Density, Buoyancy, Solutions, Diffusion
Safety Concerns: Minimal
Materials Availability: Common

Did you ever notice that when a golfer hits the ball into a water hazard, the ball sinks straight to the bottom? Would the game of golf not be more interesting if the ball floated? Since the ball cannot be changed (regulations are regulations, after all), can something be done about the water hazard? This lab demonstrates how variations in density can cause a golf ball to sink, float, or do both at once – all because of the simple physical property of density.

Content Application

- Density
- Buoyancy
- Solutions
- Diffusion

Enduring Understandings

- Density and buoyancy are intensive properties of matter, and the buoyancy of an object is related to its density.
- The density of a solution can be manipulated by the addition or removal of solute.
- Diffusion is the flow of higher concentration to lower concentration in a manner consistent with the Second Law of Thermodynamics.

Chemistry

Density is the intensive property of matter that denotes the amount of mass that occupies a given volume.

Buoyancy is the intensive property of matter that describes the net upward force of a fluid on an object [partially or fully] immersed in that fluid, resulting from the difference in pressure of the fluid between the top and bottom of the object.

If an object has a mass less than the amount of fluid it displaces when immersed, then it has buoyancy greater than its weight and will float in the fluid. In this demonstration, the addition of the mass of salt to the water does not result in a commensurate increase in its volume, which causes in an increase in the density of the liquid. Since the golf ball retains a constant density, it attains positive buoyancy when enough solute is added to the water.

Diffusion is the natural process of particles moving from higher concentration to areas of lower concentration. This is a classic example of the Second Law of Thermodynamics, which states that the entropy (disorder) of a system not in equilibrium tends to increase over time.

In this demonstration, leaving the "hover ball" undisturbed overnight is an excellent example of pure diffusion. In many systems, diffusion is disrupted by convection – that is, the movement of the matter involved transfers solute more quickly than diffusion could. However, the "hover ball" setup results in relatively stationary liquid, which is allowed to experience pure diffusion.

The concepts of **solute**, **solvent**, **solution**, **homogeneous**, **mixture**, and **solubility**, and **concentration** (**molarity**, **molality**, **normality**) can also be incorporated into this discussion.

Materials

- 6 - 1000 mL beakers or large clear drinking glasses
- Sodium chloride (table salt in a bulk box or bag is fine)
- 6 Standard Golf Balls
- Plastic spoon or large lab spoon

Safety

- Goggles – salt water splashed in the eyes can cause irritation

Procedure

This procedure should be repeated twice – once in advance of the students arrival to the classroom, and once again when demonstrating the concept. Be sure to adjust the procedure as you perform it in front of the students to address their questions (and the chemistry) as you go.

1. Fill two beakers approximately 3/4 full with tap water, and the third beaker about 1/3 of the way full.
2. Place a golf ball into each beaker. Note that all three will sink to the bottom).
3. The first beaker is the "control" with a golf ball that sinks as normal (Figure 1). Do nothing further with this beaker.

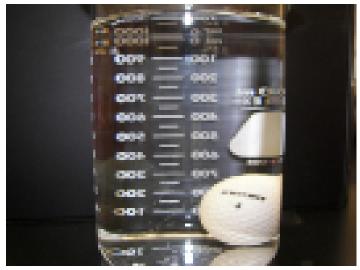

Figure 1.

4. To the second beaker, slowly add salt (stir to promote dissolving) until the golf ball floats (Figure 2). (Alternatively, you could add the salt ahead of time and add the ball afterwards – that's always an attention grabber!)

Figure 2.

5. Add salt to the water in the third beaker (as in step 4) until the golf ball floats. Then, using the back of a spoon to control the flow, *carefully* add fresh tap water over the spoon back so that it "floats" on top of the salt water (Web Enhancement Video). The result will be a golf ball that "hovers" in mid-water – it floats on the salt water while simultaneously sinking in the fresh water (Figure 3).

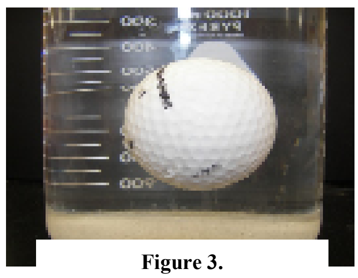

Figure 3.

You can try to float the fresh water first and then add the golf ball – this has a much great "Ooh Ahh" effect, but it must be done with extreme care or the result is mixed water that causes the golf ball to sink.

Disposal

- Salt water can be disposed of in the drain.
- Golf balls can be used thousands of times for this demo.

Follow-Up and Student Participation

Density and buoyancy have direct, easy-to-visualize impacts on students' everyday experiences. Simple examples, like boats and balloons, are easy to explain, visualize, and even demonstrate. Much more complex processes in the natural world, such as mantle convection in plate tectonics, wind patterns in the atmosphere, and sedimentation in natural waterways rely heavily on the concepts of density and buoyancy to explain them. Density can also be used to explain an example as simple as the temperature difference between the upper and lower floors of a house on a hot summer day.

Try the following follow-up activities:

1. When the demonstration is over, leave the "hover ball" to sit overnight. In the morning, the golf ball will be at the bottom as a result of the diffusion of salt through the entire volume of liquid. This effect can be enhanced by using food dye to color one half or the other of the water.

2. Confirm that the density of the water is responsible for the apparent change in buoyancy by experimentally determining the densities of the tap water, salt water, and golf ball, and comparing them in a short essay.

3. Write a short essay explaining why the concepts demonstrated in this lab might be particularly important in the design of very large ships intended to sail in both the ocean and in bodies of fresh water. Explain some of the considerations the designers will have to make, and some of the adjustments to their technique required by the men and women operating these vessels.

4. Allow students to conduct this experiment themselves, and have them carefully ascertain the mass of salt, in kilograms required in a certain volume of solution to sufficiently raise the density and result in a floating golf ball. After they have that information, ask them to determine what mass of salt might be required to sufficiently alter the density of a freshwater pond water trap on a golf course, if the pond has an assumed volume of 3.0×10^5 gallons. Finally, ask them to use the Internet as a resource to determine what the cost of that quantity of salt would be, in dollars.