Density and Buoyancy

Grade Levels

This lesson is designed for grades 6-8. The lesson has two parts and may take two to three sessions to complete.

Objectives and Topics

The objective of the first lesson is to learn about the property of density. Students will learn measurement techniques for mass and volume and organize data into tables. Students will then calculate densities and learn about fractions, ratios, and averages. Students should observe that density depends on the type of material measured, and not the amount of material. E.g. the density of a gallon of water is the same as a cup of water, while the density of a gallon of water is different from a gallon of oil.

The objective of the second lesson is to learn about the property of buoyancy. An experiment will be conducted and the data from the previous lesson will be used to show an inverse relationship between density and buoyancy. I.e. materials that are more dense are less buoyant. Students will compare the sizes of numbers and ratios. Students will recognize that numbers reflect and can predict real world phenomenon. For example, the students should be able to conclude the following: "Liquid A is more dense than liquid B so A is less buoyant than B. Therefore if liquid A is poured onto liquid B, liquid A should sink to the bottom of liquid B."

Lesson 1: Density

Lecture

Density I
We'll be learning about the density of liquids. Density is mass divided by volume or the ratio of mass to volume.

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Mass
Mass is "how much stuff is in a material." It is different from weight. Weight is "how hard stuff pushes down." For example, consider a car. Cars are made up of a lot of stuff like metal, rubber, and gasoline, so it has a lot of mass. It is very difficult to pick up so it also has a lot of weight. Now imagine the same car in outer space. This car is still made up of all the same stuff, but it is now very light since there is little gravity. So in outer space, the mass is the same, but the weight is gone. For most objects, its weight may come and go, but its mass stays the

same. Mass is usually measured in grams.

Side note
The claim that mass does not change is actually not completely true, thanks to Albert Einstein. His famous equation $E = mc^2$ states that matter/mass m is equivalent to and can be changed into a tremendous amount of energy E. This also means that whenever energy is added to any object (e.g. by speeding it up), the mass of that object increases as well.

Volume
Volume is 'how much space is there to put stuff in' or 'how much space does something take up.' Volume is usually measured in liters or cubic meters.

Density II
Density is expressed as 'mass per volume.' So, for example, if a sample of a material has a mass of 10 grams and a volume of 2 liters, then its density is

$$\frac{10 \text{ grams}}{2 \text{ liters}} = 5 \text{ grams per liter.}$$

Activity

Preparation
Many different types of volumetric containers and mass scales exist. The instructor must be proficient in type chosen for the students in this lesson.

Materials

- Graduated cylinder (1 per group)
- Mass scale (1 per group)
- Various liquids (at least 1 bottle per group, and at least 5 different liquids total)

  Recommended liquids:

  - Fresh water
  - Saturated salt water
  - Vegetable oil
  - $\geq$90% isopropyl (rubbing) alcohol
  - Corn syrup
  - Honey

Instructions
(Instructor)
1) Divide the students into groups with at least one cylinder and one scale per group.
2) Distribute the liquids to the groups. Each group should at least have 1 unique liquid.

(Student)
3) Pour out a sample of your liquid for measurement.
4) Measure its volume and mass. (Instructors may need to demonstrate.)
5) Record data in a table similar to the one below.
6) Repeat steps 3-5 for at least 3 samples.
7) Repeat steps 3-6 for other liquids (if any).

Sample data table:

Liquid: *water*

Sample	Mass	Volume	Density
1	*1.5 mg*	*1.5 mL*	*1 mg/mL*
2	*2.3 mg*	*2.3 mL*	*1 mg/mL*
3			
4			

Average density: *1 mg/mL*

Lesson 2: Buoyancy

Lecture

Note
This lecture involves a demonstration by the instructor. [*Instructions for this demonstration are in brackets like this*].

Materials

- Salt
- Water
- A clear container with a lid
- Hard boiled egg

Buoyancy
Buoyancy is "how hard stuff pushes up." Note that it is opposite to weight. [*Fill container with water and have egg ready*]. If the egg is dropped into the water, it will usually sink or float. [*Ask the students to predict what will happen*]. [*Drop egg into water*]. The egg will sink since the water is more buoyant and therefore pushes to the top more. I.e. the egg is less buoyant and pushes up less.

Buoyancy and Density
Buoyancy is related to density, in fact, we can change the buoyancy of something by changing its density. [*Remove egg from water*]. [*Add salt to water, while mixing/shaking, until no more salt will dissolve*]. Note that we

are increasing the mass a lot while changing the volume very little, and thus increasing the density. [*Ask the students to predict what will happen when the egg is dropped into the water again*]. [*Drop egg into water*]. The egg will float now. This means that salt water is less buoyant after its density is increased. In fact density is inversely related to buoyancy: things that are more dense are less buoyant and things that are less dense are more buoyant.

Activity

Preparation
Prior to the lesson, the instructor should experiment with pouring the liquids into a cylinder in various sequences. Some liquids cannot be poured after others. For example, salt water cannot be poured after fresh water. Salt water is more dense than fresh water and thus should sink through fresh water and settle beneath it. However in actuality, it mixes with the fresh water on its way down. Instead of two distinct, salt and fresh water layers, a single layer of brackish water is created. To avoid this, salt water must be poured very gently some time after the fresh water is poured. It is up to the instructor to determine which liquids have this issue.

I also recommend measuring the all the densities before hand. The last part of this activity involves predicting buoyancy from the calculated densities. If the correct densities of the liquids are not available, then the last part of this activity would be difficult to conduct properly.

Materials

- Liquids from Lesson 1 activity (each group should now have access to ALL liquids used)
- Long, thin, clear cylinder (1 per group)

Instructions
1) Draw the following table in front of the classroom.

Liquid	Average Density

2) Choose the first liquid to pour into cylinder.
3) Students pour the liquid into their cylinders.
4) Fill out table cells. E.g.

Liquid	Average Density
A	*1.5*

Where A is the name of the liquid, and the density value is obtained from the student(s) that measured it.

5) Choose next liquid.
6) Students pour the liquid into their cylinders.
7) Note where the liquid settles. Explain that it is more bouyant and less dense than all liquids below it. It is

also less buoyant and more dense than all liquids above it.

We should observe liquid B sinking below A here.

Liquid	Average Density
A	*1.5*
B	*2.4*

8) Repeat steps 5-7 for until half of the liquid types are used.
9) Choose next liquid.
10) Fill out table cells (before pouring this time). E.g.

Liquid	Average Density
A	*1.5*
B	*2.4*
C	*1.9*

11) Ask students to predict where the liquid should settle.

Liquid C should settle above B and below A in this example.

12) Students pour the liquid into their cylinders.
13) Repeat steps 9-12 until all liquids are used.

Side note
What does this tell us about the density of a giant steel battleship versus sea water? *Sea water is more dense than a battleship.* What does this tell us about the density of water as it freezes into ice? *Since ice floats on water, the act of freezing must decrease the density of water.*