Density Column

Demonstration

This surprising demonstration illustrates the relationship between densities and buoyant forces.

NASA super pressure balloon (NASA/Bill Rodman)

Number of Participants: 1-30

Audience: Middle (11-13) and up

Duration: 5-10 min

Difficulty: Level 2

Materials Required:

- Large, clear glass container
- Liquids of various densities
  a. Corn Syrup[1] (1.33 g/cm^3)
  b. Water[2] ($1.00\ g/cm^3$)
  c. Vegetable oil[3] ($0.92\ g/cm^3$)
  d. Air[2] ($0.0012\ g/cm^3$)
- Solids of various densities
  a. Ball bearing[2] (Steel; $7.88\ g/cm^3$)
  b. Grape[4] ($1.13\ g/cm^3$)
  c. Bottlecap[5] (0.94-$0.96\ g/cm^3$)
  d. Ping-pong ball[6] ($0.081\ g/cm^3$)

Setup:

1. Carefully add the various liquids and objects as the participants watch. Avoid mixing. *Note: This demonstration will need to be setup on site, as it does not travel well.*

Presenter Brief:

Understand different states of matter, mixtures, and how density relates to buoyancy. Compare the provided densities for each component so that relative differences can be explained.

Vocabulary:

- Density – The mass per unit volume of matter. SI Units: g/cm^3.
- Solid – A state of matter characterized by rigid and tightly packed particles.
- Liquid – A state of matter characterized by free and moderately packed particles.

Physics & Explanation:

Middle (11-13) and general public:

The three most common states of matter are solids, liquids, and gasses. One way to identify these different states is by observing how tightly packed their particles are and how free they are to move.

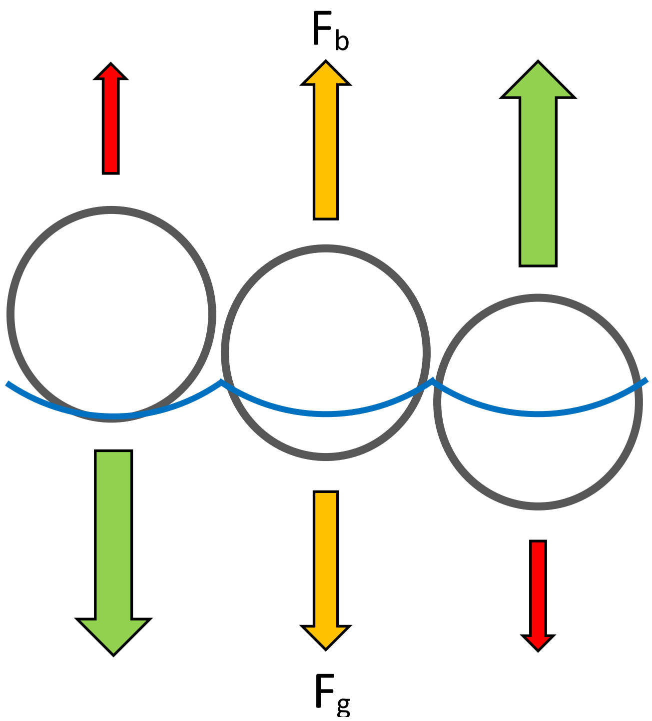
> Ask the participants to identify some things that float in water. Challenge them to think about why some objects float and some objects sink. Ask if they know that some other liquids can float or sink in water. Extend the discussion by asking why balloons float. Ask what would happen to a floating balloon if it were immersed in water, corn syrup, or set out in space; would the balloon tend toward any direction?
>
> Ask why most wood floats in water, but some does not. Make sure to emphasize that the crucial element is the ratio of mass to volume: the density.

Fluids tend to separate based on their density; fluids with lighter densities than another liquid will float, and more dense fluids will sink.

Some liquids, like solids, can either float or sink in water. It depends on the liquid's density. For example, honey sinks in water because it is denser If you've ever seen a balloon or a blimp in the sky, it's because it contains lighter gases such that its overall density is less than that of regular air. When something like a balloon pops, it lets go of all those lighter fluids, and falls because there is nothing else pushing the object upward.

Highschool (14 +):

After completing the previous section, explain that the upward force holding each object is the buoyant force (F_b) and that it opposes the gravitational force (F_g). When these forces are equal in magnitude, the object ceases to rise or sink, and simply floats.



🔑 The buoyant force is an upward force from a fluid.

The buoyant force experienced by an object depends on the density and volume of the object. The buoyant force pushes an object up, and gravity pulls an object down. Hollow objects usually float because they have a low mass and high volume: they are not very dense.

Show the buoyancy equation and point out density and volume in the equation. Ask participants to consider how adjusting the physical parameters of the object (mass and volume) would affect the buoyant force.

$$F_b = \rho V g$$

🔑 If the weight of the object is greater than the buoyant force, the object will sink. If the weight of the object is lesser than the buoyant force, the object will float.

Additional Resources:

Common Densities:

Material	Density (g/cm^3)	State
Air[2]	0.0012	Gas

Oxygen[2]	0.0014	Gas
Ozone[2]	0.0021	Gas
Ping-pong ball[6]	0.081	Solid
Rubbing alcohol[7]	0.79	Liquid
Lamp oil[7]	0.81	Liquid
Baby oil[7]	0.83	Liquid
Vegetable oil[3]	0.92	Liquid
Ice cube[7]	0.92	Solid
Bottlecap[5]	0.95	Solid
Water[2]	1.00	Liquid
Milk[7]	1.03	Liquid
Dish soap[7]	1.06	Liquid
Grape[4]	1.13	Solid
Corn syrup[1]	1.33	Liquid
Maple syrup[7]	1.37	Liquid
Honey[1]	1.42	Liquid
Ball bearing[2]	7.88	Solid

- Finding Density https://serc.carleton.edu/mathyouneed/density/index.html
- Volume-changing demonstration with liquid nitrogen https://www.youtube.com/watch?v=TVZhRVisof4
- [1]https://ndb.nal.usda.gov/ndb/foods/show/6326
- [2]Weast, Robert C. et al. *Handbook of chemistry and Physics*, CRC Press. 60th ed., 1980. (p F-3, F-11, F-80, E-122)
- [3]https://ndb.nal.usda.gov/ndb/foods/show/682
- [4]https://ndb.nal.usda.gov/ndb/foods/show/2241
- [5]Hasset, Jacob. Kay, Benjamin. *At What Point do Floating Plastics Sink?* Web, 2010. http://www.teammarine.org/wp-content/uploads/2012/03/Plastic-Buoyancy-Research_Press-Release_TM-09-101.pdf
- [6]https://pongworld.com/table-tennis-sport/rules
- [7]https://www.stevespanglerscience.com/lab/experiments/seven-layer-density-column/

Useful Equations:

Density	$\rho_s = \frac{m}{V}$
Buoyant Force	$F_b = \rho_f V g$

$m = total\ mass$

$V = volume$

$g = acceleration\ due\ to\ gravity$

$\rho_f = density\ of\ the\ fluid$

$\rho_s = density\ of\ the\ solid$