# Buoyancy Experience

**We will throw OBJECTS in the WATER to see which ones float and which ones don't to understand why one object floats and another one doesn't.**

**OBJECTIVES:**

Understand at a basic level why some objects float in water and others do not.

Introduce the concept of density.

**LEARNING OUTCOMES**

Preliminary knowledge of the concepts of buoyancy and density.

Know to organise simple experimental work.

Know the scientific method on an introductory level.

Learn how to take data.

Be able to represent some data graphically.

Can analyse certain data and draw conclusions.

**PREREQUISITES**

None specific. Mathematical calculations are not required. However, you will need read and record numerical data during the exercise.

**APPROXIMATE TIME**

45 - 75 minutes.

**STRUCTURE OF THE DOCUMENT**

# Introduction

How is it possible for a ship to float and a marble to sink?

If a boat is made of iron and a marble is made of glass, why is one of them floating and the other sinking?

## Experiment development

You have to access the "Basic Buoyancy" laboratory in LabsLand. Then, you have to carry out the experiment with the objects in the table and indicate for each of them if it floats or sinks after being made to descend

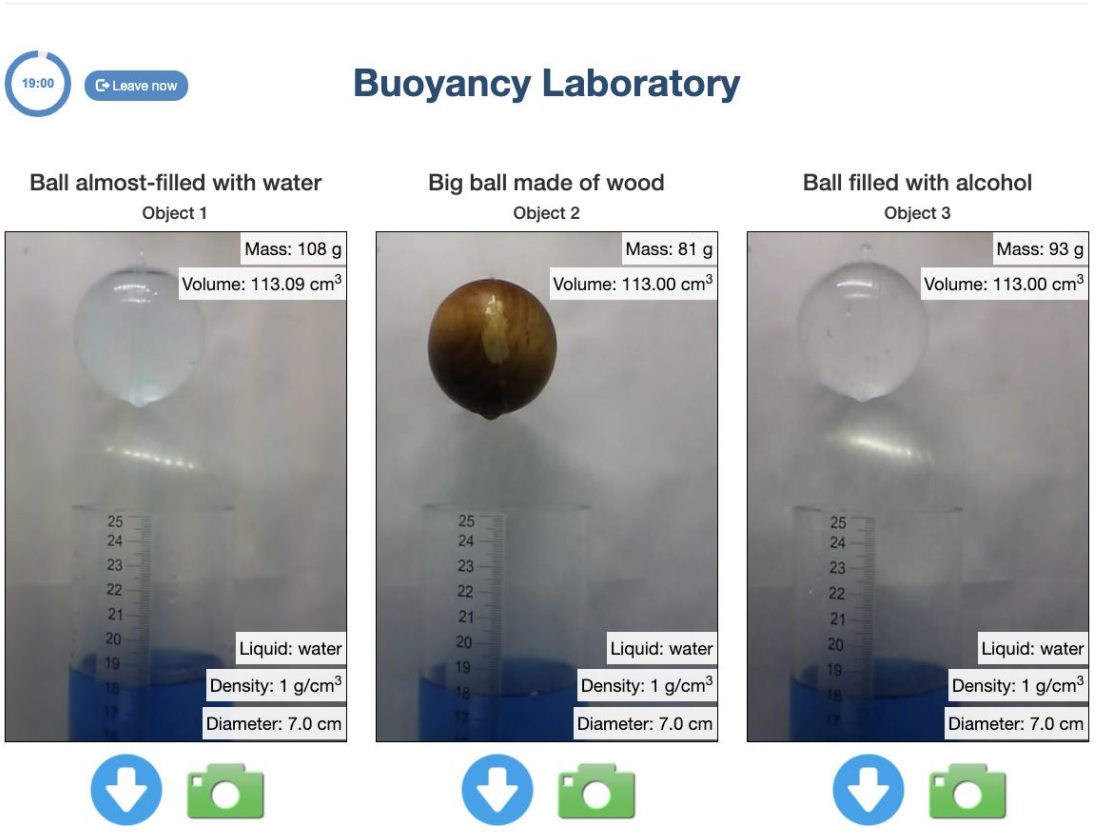



*Figure 1. The user interface of the Buoyancy Basic remote laboratory.*

First, the teacher will show how to use the laboratory to conduct the experiment. He will do a test with the students entering in the lab and and taking out some objects from the liquid.

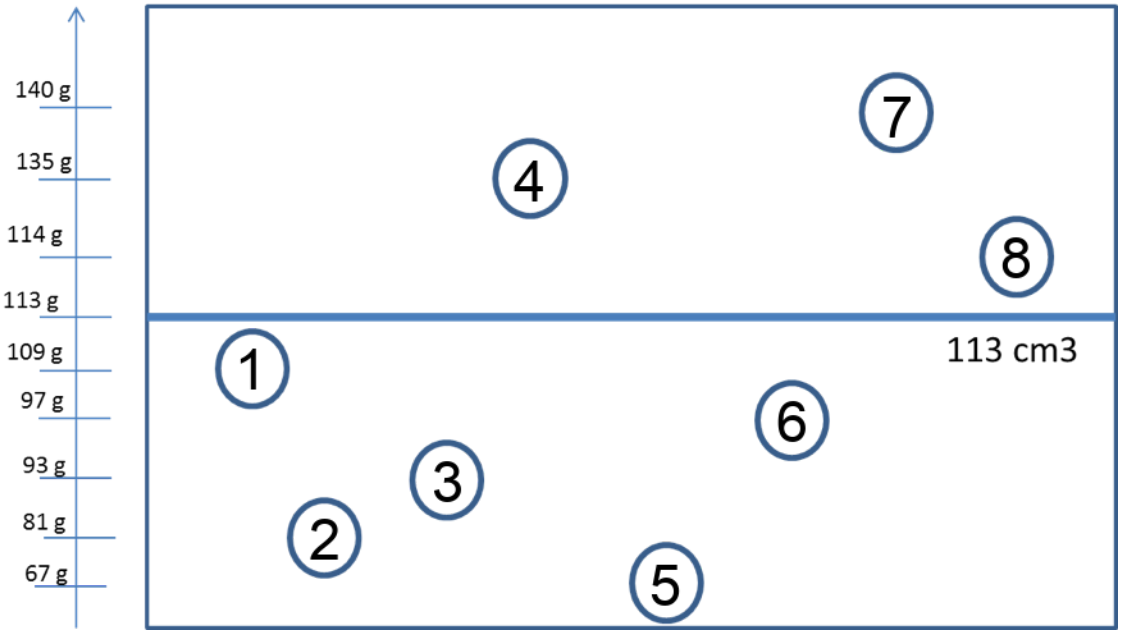
Then, he will ask the students to experiment on their own, and to fill in a table like the one below, indicating whether the object floats or sinks when it is introduced into the liquid.

| Object | Mass | Volume | It sinks | It floats |
|---|---|---|---|---|
| Object 1: Ball almost full of water. | 108,9 g | 113,09 $cm^3$ | | |
| Object 2: Large wooden ball | 81,4 g | 113,09 $cm^3$ | | |
| Object 3: Ball filled with alcohol | 93,2 g | 113,09 $cm^3$ | | |
| Object 4: Ball full of marbles | 135 g | 113,09 $cm^3$ | | |
| Object 5: Ball half full of marbles | 67,4 g | 113,09 $cm^3$ | | |
| Object 6: Ball with some marbles | 97,1 g | 113,09 $cm^3$ | | |
| Object 7: Glycerine-filled ball | 140,2 g | 113,09 $cm^3$ | | |
| Object 8: Water-filled ball | 113,9 g | 113,09 $cm^3$ | | |

## Graphical representation of data

As you can see in the image below, the y-axis represents the mass of the objects. All objects have the same volume. The x-axis and the blue horizontal line represents the boundary of the objects.

Paint each object of the figure green if it floats or red if it sinks.




## Results analysis

It is seen that all the objects thrown have the same volume. However, some of them float and some of them sink, why does this happen?

How much mass has each floating objects? Is the mass higher or lower than the volume?

How much mass has each sinking objects? Is the mass higher than the volume or vice versa?

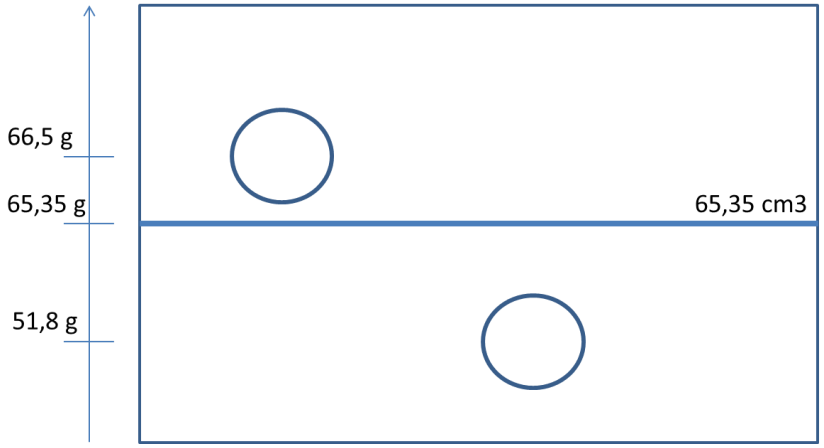
Relative to the center line, where are all the green objects? and where are the red objects?

If you throw a new object and you know its mass and volume, can you tell if it will float or not?

## Evaluation

1. Repeat the experiment with two objects with the same volume (although different from the experiment done in class). Write inside each ball the number of the object it represents.

| Object | Mass | Volume | It sinks | It floats |
|---|---|---|---|---|
| Object 10: Small white ball | 66,5 g | 65,5 $cm^3$ | | |
| Object 11: Small wooden ball | 51,8 g | 65,5 $cm^3$ | | |



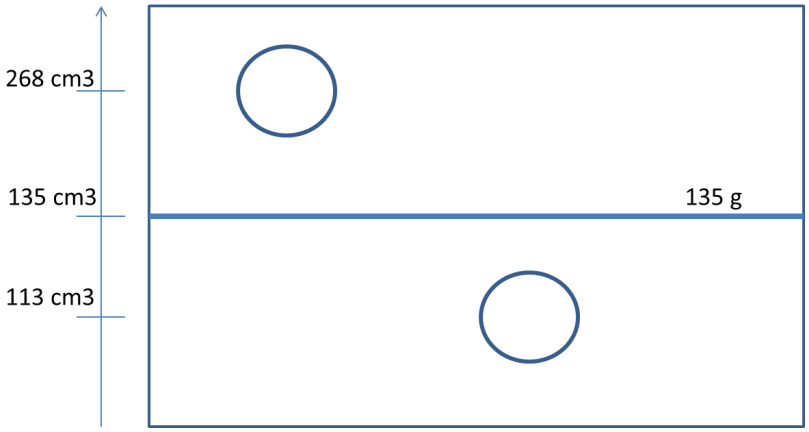

Add what you have observed to the previous graph and think if these new objects perform like the previous ones, which will be the red object? and the green one? does its position coincide with the other objects position in relation to the volume line?

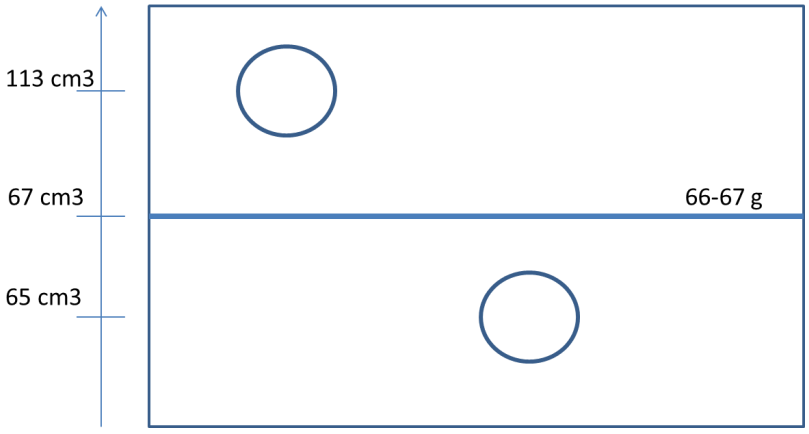
2. The following table shows objects that have approximately the same mass and different volumes. Color them green or red depending on whether they float or sink. In addition, write inside each ball the number of the object it represents.

| Object | Mass | Volume | It sinks | It floats |
|---|---|---|---|---|
| Object 9: Big ball half full of marbles | 135 g | | | |
| Object 4: Ball full of marbles | 135 g | | | |

| | | | | |
|---|---|---|---|---|
| Object 10: Small white ball | 66,5 g | | | |
| Object 5: Ball half full of marbles | 67,4 g | | | |

In this case, the y-axis represents the volume of the objects. In the first picture we see the two objects with different volumes but with the same mass, inside an area representing a mass of 135 grams. In the second picture, the same thing happens, but this time the objects have a mass between 66 and 67 grams.




Does an object floats or sinks depend only on mass?

3. New objects appear in the following table. First write down their masses and volumes and then, based on what you have learned, say whether they will float

or sink when they are thrown (complete the table). Do this exercise without throwing the objects (first make the hypothesis) and without looking at the previous tables in case the object has already been tested. Then throw them and check if you got it right or not.

| Object | Mass | Volume | It sinks | It floats |
|---|---|---|---|---|
| Object 9: Big ball half full of marbles | | | | |
| Object 13: Cork ball | | | | |
| Object 12: Polystyrene ball | | | | |
| Object 4: Small white ball | | | | |
| Object 10: Ball full of marbles | | | | |

Think about if these new objects behave like the previous ones: to which of the objects does the red colour correspond? and the green colour? does their position coincide with that of the objects in the first experiment?

Are the following statements true or false?

If the volume is higher than the mass then it floats: TRUE OR FALSE

If the volume is higher than the mass then it sinks: TRUE OR FALSE

If the volume is less than the mass then it floats: TRUE OR FALSE

If the volume is less than the mass then it sinks: TRUE OR FALSE

## Open Questions

1. Write the rule to know if an object will float or not. Look up and explain the concept of DENSITY.
2. Relate the words DENSITY and BIG, SMALL, LIGHT, WEIGHTY, MASSIVE, etc.
3. If one object floats more than another, then how is the density of the first object compared to the second? more or less?

4. Why does a ship float if it is very large?
5. Why is a submarine able to sink or float, and how does it do so?
6. Why don't we sink in a swimming pool or in the sea? do you have the feeling that you almost sink? why? what is the human body mostly made of? what do you think is approximately the density of the human body?
7. Do you think a single marble will float if you throw it into the water? Note that a marble has a density of approximately 2.5 g/cm$^3$ and the density of water is 1 g/cm$^3$.
8. Why does a ball with some marbles float? If a marble has a mass of about 7 grams, how many will fit in the 113 cm$^3$ sphere?
9. The sphere of the experiment can be opened. If we only use one half of an open sphere to fill it with marbles, will the half sphere float the same? How many marbles will fit in this case?

## Teacher's notes

1. An object floats if its volume in cubic centimetres ($cm^3$) is higher than its mass weight in grams (g) (only if the liquid is water or with a density of 1 $g/cm^3$).
2. The idea is to always work with the same volume so that they can see that floating does not depend only on the size, just on the mass versus volume.
3. Then the same thing is done with the same mass.
4. The idea is that the student observes, measures, notes and thinks. One result of thinking is that the student should be able to predict (by means of a hypothesis) what will happen to a new object without throwing it, although he or she will then throw it to check it.
5. That is why there is a table with two last new objects: the risk of the previous point is to paint (predict) the circles first and then see if they float or sink (experiment). In the first step, we have first launched and then painted. Observing and thinking gives us an advantage over nature.
6. The pupil can' t know a priori if a marble is going to float or not, but if we give him one, he may intuit it by noting the weight and how solid it is.
7. To graph the data, it can be interesting to have a mural prepared in class and have each student take coloured rubber bands and stick them on the mural. The student will write the numbers of the objects on the appropriate coloured rubber bands. There can also be group murals to compare between groups.
8. Talking about boats means changing the scale of the pupil and that is difficult. In addition, talking about boats allows us to introduce the concept that air exists and weighs, even if it is relatively little. For this we can have an empty ball and throw it into the water in class, and then repeat the same with the ball filled with sand or marbles.
9. A submarine floats because part of it is filled with air. A submarine has tanks that when filled with air make the submarine float but when it is filled with water then the submarine sinks because its mass increases. To fill and empty the tanks the submarine has pumps. When it is at the sea bottom it activates pumps to draw water out of the tanks and pressurise air in, thus decreasing its mass to the point where it floats the boat.

10. The assessment is extensive and includes objective questions, for the first four, and subjective questions, for the second four. It is best for the teacher to tailor the assessment to his or her course and level.

11. A marble has the density of glass, approximately 2.5 g/cm$^3$ and therefore sinks when water is thrown on it. If we put a single marble into the 113cm$^3$ sphere, then the density of the whole will be 2.5/113, or about 0.02 g/cm$^3$, i.e. it will float a lot. If we put 16 marbles in, then the total mass will be 112 grams, and so the ball may or may not float.