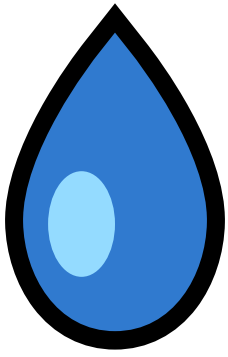
Learning and Evaluation Situation

Science and Technology

Elementary, Cycles 2 and 3

Mysterious Layers

The Buoyancy of Fluids



Teacher's Guide

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Grade:	Elementary, Cycles 2 and 3
Subject:	Science and Technology
Activity Duration:	100 minutes

Activity Summary

Teaching Aim

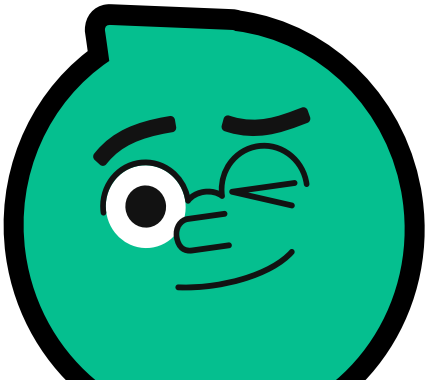
Students often imagine the buoyant force in fluids as a simple concept: "*A light liquid will float in water and a heavy liquid will sink.*" The goal of this LES is to show students that neither mass nor volume alone determine the buoyant force in fluids. Buoyancy depends on mass and volume, which combine to form a property called ***density***.

This LES is done in two parts:

- In the **first experiment**, students observe how mass affects the buoyant force in three different liquids of equal volume.
- In the **second experiment**, students observe how volume affects the buoyant force in three different liquids of equal mass.

Important:

Students must complete both experiments in this LES. Doing only the first experiment could reinforce the mistaken belief that a "*light liquid will float in water and a heavy liquid will sink.*" Both experiments must be done to dismantle this misconception and reinforce the fact that "*liquid that are less dense than water will float in water, while liquids that are denser than water will sink..*"



Key Concepts

- Discern **mass** and **volume**
- Distinguish between mixtures of miscible and **immiscible liquids** (e.g. water and milk, water and oil)

Key Techniques

- Measure **mass** with an electronic scale
- Measure **volume** with a graduated cylinder

Learning Objectives

- Understand the combined role of **mass** and **volume** in the **buoyant force** of fluids
- Associate relative buoyancy in a liquid with its **density**

Step	Duration
Scenario	10 min.
Form teams	5 min.
Experiment 1	30 min.
Experiment 2	30 min.
Review of Experiments 1 and 2	10 min.
Density and Buoyancy	15 min.

Procedure

Scenario

Approx. 10 minutes

Together, the class reads through the entire scenario and Experiment 1.
The teacher ensures that the students fully understand the experiment.

Form teams

Approx. 5 minutes

The students will need to pair up for this activity.

Experiment 1

Approx. 30 minutes

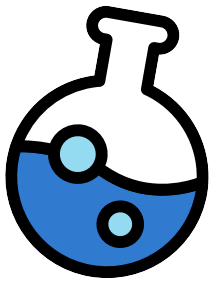
In Experiment 1, students observe that in immiscible liquids of equal volume, the lighter liquid will stay on top of the heavier one.

When the volume of the liquids is equal, mass determines buoyancy, since mass is the only variable affecting density. In this situation, the heavier liquid is also denser.

1. Materials and Equipment

List of Materials and Equipment

- 100 mL of liquid A
- 100 mL of liquid B
- 100 mL of liquid C
- A scale
- A large container



Teacher Preparation Ahead of the Experiment

To Do	Advantage
Add colour to liquids A, B and C.	- Substances are easier to identify - Students' sketches are clearer
Pre-weigh the mass of the empty containers for A, B and C. Label each container with its mass.	- Students will not have to transfer the liquids themselves - Saves time by eliminating a step from the students' tasks
Pour the exact volume of each liquid directly into its container (recommended amount: 100 mL).	- Saves time by eliminating a step from the students' tasks - Prevents student error in accurately measuring volume

Recommended Liquids for the Experiment

Depending on the resources available to the teacher, different liquids can be used to carry out this experiment. However, the selected liquids must meet the following criteria:

- The three liquids must be immiscible. Mixing the liquids must result in three distinct layers.
- Liquid densities must be varied enough for students to be able to measure a sufficiently distinct mass for each liquid.
- The three liquids must be non-volatile and non-toxic, to ensure students' safety.

The following table shows the recommended liquids for this experiment, along with their properties.

Table 1. Properties of Liquids A, B, and C

	Liquid	Density at 20°C (g/mL)	Volume (mL)	Expected Mass (g)	Added Colouring
Liquid A	Water	1.0	100	100	Pink food colouring[1]
Liquid B	Mineral oil	0.8 to 0.9	100	80 to 90	Turmeric[2]
Liquid C	Coloured dishwashing liquid	1.1 to 1.2	100	110 to 120	Already coloured[3]

[1] The selected colouring must be water-soluble. Food colouring solutions used in cooking or baking are usually suitable.

[2] In this case, the food colouring agent must be solid in form. Food colouring solutions are usually water-based and will not dissolve in oil.

[3] It is difficult to obtain a uniform blend by adding colour to dishwashing liquid. It is better to use a dishwashing liquid that is already coloured. If liquids A and B are coloured, you can use a clear dishwashing liquid for the experiment.

Important to know!

The volume of the three liquids:

- must be equal, since students will calculate mass for a constant volume of liquid;
- must be at least 100 mL, so that the liquids are of sufficiently different mass for students to be able to tell them apart, even if they spill some.

Teacher reminder:

Always do a test run before having students perform the experiment.
This will help you anticipate any potential problems as well as the questions your students may have.

Other Recommendations

The following table provides recommendations for the rest of the equipment needed to perform Experiment 1.

Table 2. Recommended Equipment

Equipment	Recommendation
A scale	A kitchen scale or another type of electronic scale
A large container	A clear container that can hold at least 400 mL (e.g., beaker, plastic jar, large glass)

A kitchen scale is inexpensive and will be easy for students to use.

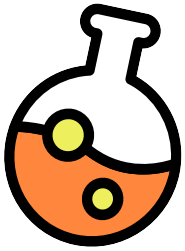
2. Finding the Mass of Liquids

Before the students begin, the teacher reminds them of the following safety precautions:

- Do not ingest any of the substances.
- Do not touch the substances with their hands.
- Treat equipment carefully and avoid pressing on the scale with their hands.

If needed, the teacher can show students how to use the scale.

Throughout the experiment, the teacher makes sure students are entering the mass values in the correct place in the data table. The teacher also ensures that students do their calculations correctly.



3. Finding the Buoyancy of Liquids

Writing the Hypothesis

The teacher ensures that students finish writing their hypotheses before they mix the liquids. Students are encouraged to use coloured pencils to identify the liquid layers. The teacher also ensures that each layer is clearly labelled (*liquid A, liquid B, liquid C*).

Manipulations and Results

The expected results are as follows. Again, the teacher makes sure students have correctly identified each liquid (A, B, and C) in their drawings.

Note that the three liquids have the same volume.

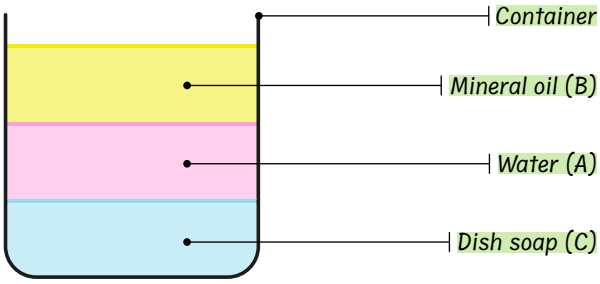


Figure 1. Expected result for Experiment 1

4. Analyzing Results

To guide the students

Analysis	Questions to Guide Students	Indications
a. The three liquids are of [*equal volume / different volume*].	What is the volume of the liquids? Where can you find this value?	The volume of the liquids is available in the list of materials and equipement.
b. The three liquids are of [*equal mass / different mass*].	What is the mass of the liquids? Where can you find these values?	The mass of each liquid is listed in the data table.
c. Liquid [*A / B / C*] is the heaviest. It is [*on the top / in the middle / at the bottom*] of the container. d. Liquid [*A / B / C*] is the lightest. It is [*on the top / in the middle / at the bottom*] of the container.	What property do the adjectives *heavy* and *light* describe? Where can you find the mass values to compare them?	The adjectives *heavy* and *light* are used to describe mass. The mass of each liquid is listed in the data table.

Results Analysis Answer Key

a. The three liquids are of [~~*equal mass*~~ / *different mass*].

b. The three liquids are of [*equal volume* / ~~*different volume*~~].

c. Liquid [~~*A*~~ / ~~*B*~~ / *C*] is the heaviest.
It is [~~*on the top*~~ / ~~*in the middle*~~ / ~~*at the bottom*~~] of the container.

d. Liquid [~~*A*~~ / *B* / ~~*C*~~] is the lightest.
It is [*on the top* / ~~*in the middle*~~ / ~~*at the bottom*~~] of the container.

5. Conclusion

Conclusion Answer Key

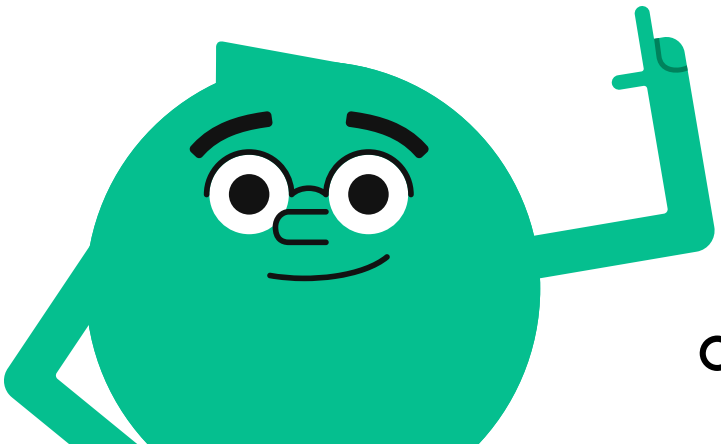
This experiment proved that, among liquids of [~~*equal mass*~~ /*equal volume*], [*mass* / ~~*volume*~~] determines buoyancy. The lighter liquid [*floats*/~~*sinks*~~] while the heavier liquid [*sinks*/~~*floats*~~].

However, this experiment does not tell us if [~~*mass*~~ /*volume*] determines buoyancy, because liquids A, B, and C all had [~~*equal mass*~~ / *equal volume*].

Note

By the end of Experiment 1, students understand that mass affects the buoyant force of liquids. It is important to complete this concept so that they know this is only true when volume is constant. **Density**, rather than mass alone, determines the buoyant force in liquids.

Experiment 2 is crucial for understanding the role of volume in the buoyancy of objects.



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Experiment 2

Approx. 30 minutes

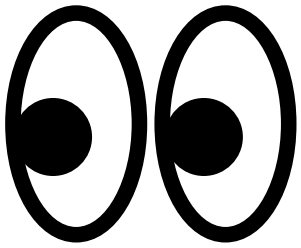
In Experiment 2, students will learn that in immiscible liquids of equal mass, the liquid with more volume will stay on top of the liquid with less volume.

In liquids of equal mass, volume determines buoyancy, since volume is the only variable affecting density. In this situation, the smaller volume of liquid is also denser.

1. Materials and Equipment

List of Materials and Equipment

- 100 g Liquid A
- 100 g Liquid B
- 100 g Liquid C
- A graduated cylinder
- A large container
- Paper towels



Teacher Preparation Ahead of the Experiment

To Do	Advantage
Add colour to liquids A, B and C.	- Substances are easier to identify - Students' sketches are clearer
Pre-measure the mass of each liquid directly in its container (recommended amount: 100 g).	- Saves time by eliminating a step from the students' tasks - Prevents student error in accurately measuring mass

Recommended Liquids for the Experiment

Depending on the resources available to the teacher, different liquids can be used to carry out this experiment.

The following table shows the recommended liquids for this experiment, along with their properties. These are the same liquids as in Experiment 1.

Table 3. Properties of Liquids A, B, and C

	Liquid	Density at 20°C (g/mL)	Mass (g)	Expected Volume (mL)	Added Colouring
Liquid A	Water	1.0	100	100	Pink food colouring[1]
Liquid B	Mineral oil	0.8 to 0.9	100	111 to 125	Turmeric[2]
Liquid C	Coloured dishwashing liquid	1.1 to 1.2	100	83 to 91	Already coloured[3]

[1] The selected colouring must be water-soluble. Food colouring solutions used in cooking or baking are usually suitable.

[2] In this case, the food colouring agent must be solid in form. Food colouring solutions are usually water-based and will not dissolve in oil.

[3] It is difficult to obtain a uniform blend by adding colour to dishwashing liquid. It is better to use a dishwashing liquid that is already coloured. If liquids A and B are coloured, you can use a clear dishwashing liquid for the experiment.

Important to know!

The mass of the three liquids:

- must be equal, since students will calculate volume for a constant mass of liquid;
- must be at least 100 g, so that the three liquids are of sufficiently different volume for students to be able to tell them apart, even if they spill some.

Teacher reminder:

Always do a test run before having students perform the experiment.
This can help anticipate potential problems as well as students' questions.

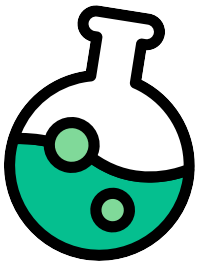
Other Recommendations

The following table shows recommendations for the rest of the equipment needed to perform Experiment 2.

Table 4. Suggested Equipment

Equipment	Recommendation
Graduated cylinder	To avoid broken equipment, it is best to use a graduated cylinder made of plastic. The capacity of the graduated cylinder must be at least 150 mL.
A large container	A clear container that can hold at least 400 mL is recommended (e.g., a beaker, plastic jar, or large glass). The expected total volume will be around 300 to 320 mL.

If needed, the teacher can show students how to read volume measurements on a graduated cylinder.



2. Finding the Volume of Liquids

Before the students begin, the teacher reminds them of the following safety precautions:

- Do not ingest any of the substances.
- Do not touch the substances with their hands.

If necessary, the teacher can show students how to measure volume with a graduated cylinder.

During the experiment, the teacher ensures that students use the graduated cylinders correctly. Between each volume measurement, the teacher ensures that students pour all of the liquid back into its original container, and that the graduated cylinder is thoroughly cleaned. To facilitate clean-up, measure the volume of liquid A (water), followed by B (oil), and lastly C (dishwashing liquid).

Once liquid C has been poured into the graduated cylinder, there is no need to pour it back into its original container. It can be poured directly into the large container where the three liquids will be mixed. Since liquid C, the dishwashing liquid, is viscous, it helps prevent spillage.

3. Finding the Buoyancy of Liquids

Writing the Hypothesis

The teacher ensures that students finish writing their hypotheses before they mix the liquids. Students are encouraged to use coloured pencils to identify the liquid layers. The teacher also ensures that each layer is clearly labelled (*liquid A, liquid B, liquid C*).

Manipulations and Results

The expected results are as follows. Again, the teacher makes sure students have correctly identified each liquid (A, B, and C) in their drawings.

The drawing shows that the three liquids have different volumes. The liquid with the most volume is at the top of the mixture, while the liquid with the least volume is at the bottom.

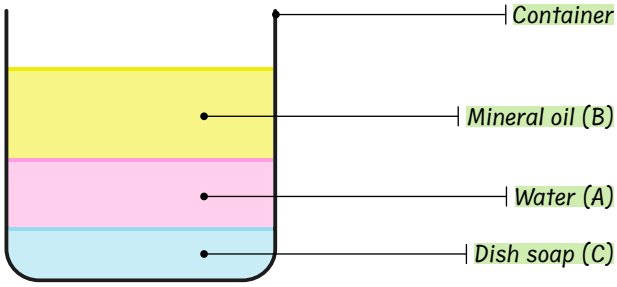


Figure 2. Expected Result for Experiment 2

4. Analyzing Results

To guide the students

Analysis	Questions to Guide Students	Information
a. The three liquids are of [equal mass / different mass].	What is the mass of the liquids? Where can you find this value?	The mass of the liquids is available in the list of equipment.
b. The three liquids are of [equal volume / different volume].	What is the volume of the liquids? Where can you find these values?	The volume of the liquids is listed in the data table.
c. Liquid [A / B / C] has the most volume. It is [on the top / in the middle / at the bottom] of the container. d. Liquid [A / B / C] has the least volume. It is [on the top / in the middle / at the bottom] of the container.	Where can you find the volume values to compare them?	The volume of the liquids is listed in the data table.

Results Analysis Answer Key

a. The three liquids are of [*equal mass* / ~~*different mass*~~].

b. The three liquids are of [~~*equal volume*~~ / *different volume*].

c. Liquid [~~*A*~~/*B*/~~*C*~~] has the most volume.
It is [*on the top* / ~~*in the middle*~~ / ~~*at the bottom*~~] of the container.

d. Liquid [~~*A*~~/~~*B*~~/*C*] has the least volume.
It is [~~*on the top*~~ / ~~*in the middle*~~ / *at the bottom*] of the container.

5. Conclusion

Conclusion Answer Key

This experiment proved that in liquids of [*equal mass* / ~~*equal volume*~~], [~~*mass*~~ / *volume*] determines buoyancy. The larger volume of liquid [*floats* / ~~*sinks*~~] while the smaller volume of liquid [*sinks* / ~~*floats*~~].

However, this experiment does not tell us if [*mass* / ~~*volume*~~] determines buoyancy, because liquids A, B, and C all had [*equal mass* / ~~*equal volume*~~].

Note

By the end of the experiment, students will understand how volume affects the buoyant force of liquids. They might be surprised to learn the following points:

- When mass is constant, larger volume corresponds to the liquid that will float.
- Although the liquids all weigh the same, the buoyant force is different for each of them. This challenges the mistaken belief that "*a light liquid floats in water and a heavy liquid sinks*."

Review of Experiments 1 and 2

Approx. 10 minutes

The two experiments show students how mass and volume affect buoyancy. Review the lesson so that they notice how the two properties combine in the form of density, which determines the buoyant force in liquids.

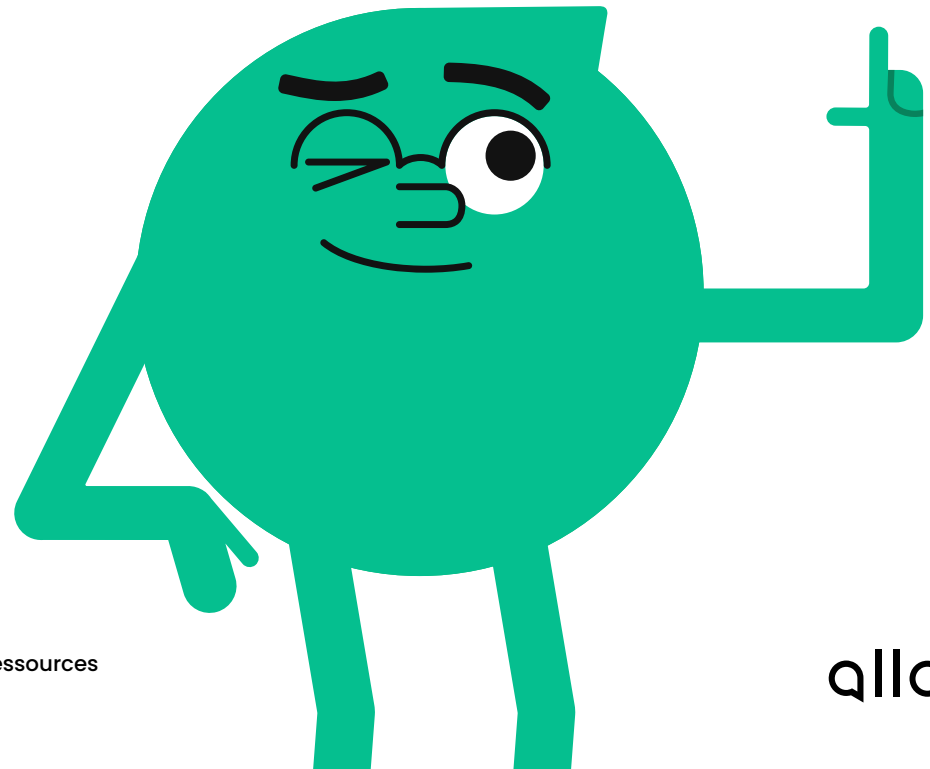
Question 1 Answer Key

Experiment 1 showed that [*mass* /~~*volume*~~] determines the order in which liquids of [~~*equal mass*~~ / *equal volume*] form layers.

Experiment 2 showed that [~~*mass*~~ / *volume*] determines the order in which liquids of [*equal mass* / ~~*equal volume*~~] form layers.

Considering the results of both experiments, it is true that [~~*only mass*~~ / ~~*only volume*~~ / *mass and volume*] will determine the order in which liquids form layers.

The property comprising both these properties of matter is called *density*.

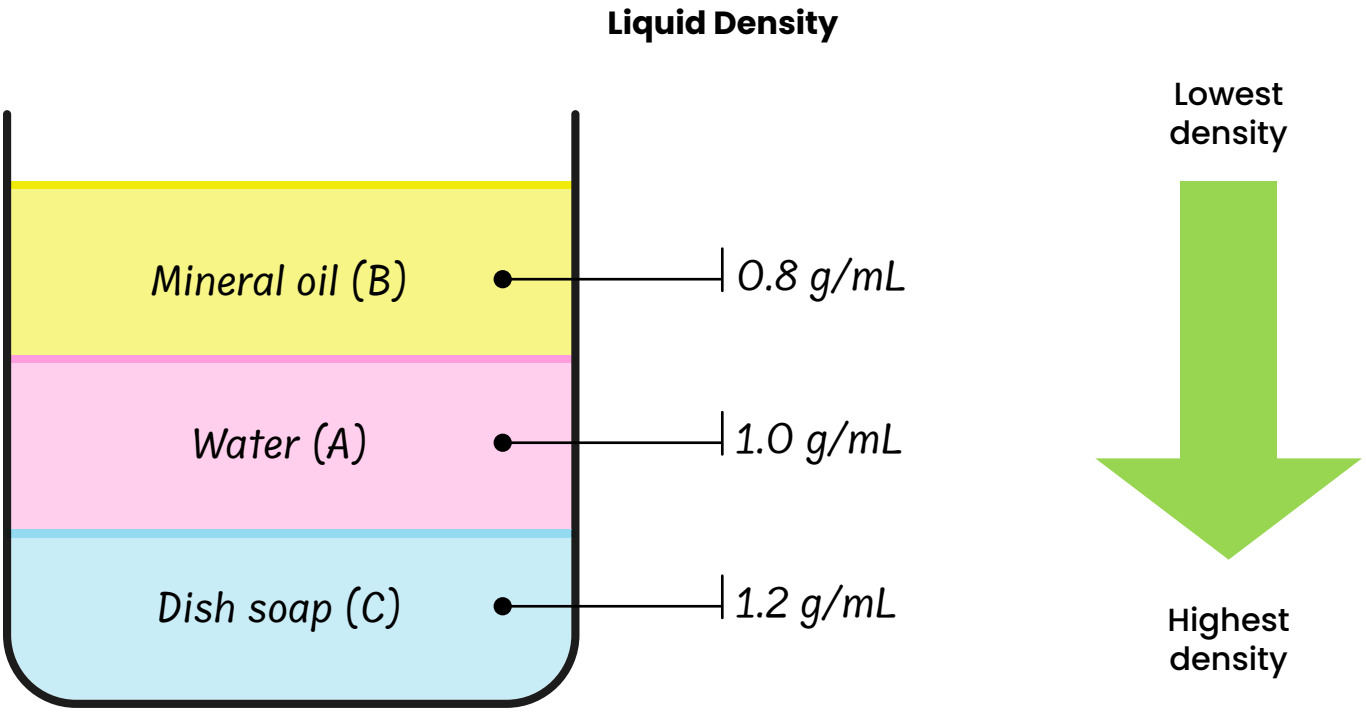


Density and Buoyancy

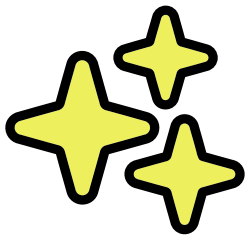
Approx. 15 minutes

After the review, the teacher defines density and its role in the buoyant force of liquids, indicating the density of the three liquids in Experiment 1 and Experiment 2.

Question 2 Answer Key



The densities provided above apply to the recommended liquids for the experiment. The teacher may choose different liquids and indicate their respective densities.



Question 3 Answer Key

Liquid [~~A~~ / B / ~~C~~] has the **lowest** density.
Because of this, it rises to **the top** of the mixture.

The density of liquid [A / ~~B~~ / ~~C~~] is somewhere **between** the densities of the other two liquids.
Because of this, it stays in **the middle** of the mixture.

Liquid [~~A~~ / ~~B~~ / C] has the **highest** density.
Because of this, it sinks to **the bottom** of the mixture.

Dive Deeper!

To complete their course on density and buoyancy, teachers may consult the following Alloprof concept sheets (French only):

- La masse volumique | Primaire
- La flottabilité | Primaire

The teachers could tie in the following topics:

- The concept of density
- Classifying solids of equal volume according to density
- Classifying solids of equal mass according to density
- Density's effect on the buoyant force of substances