**Lesson 7 – Relating Density to Floating and Sinking of Solids**

**Storyline Summary:**

Students now understanding that density is the relationship between mass and volume and that density can be used to predict sinking and floating in liquids.

Explain to students that a better understanding of different aspects of density and how it relates to sinking and floating will be key to understanding how the Lava Lamp works. A reason to explore further into density helps propel the Lava Lamp storyline.

The main focus of this lesson is for students to understand that the density of the object and the density of the liquid it is placed in, both need to be considered in predicting whether the object will sink or float. Students see that the same float-and-sink rules apply for solids placed in liquids as liquids placed in liquids.

The lesson also emphasizes that the size, mass, and arrangement of the atoms and molecules of the object and the liquid are key to their density and therefore to whether the object sinks or floats. In making sense of the science and modeling their understanding, students acquire a deeper understanding of how to analyze different phenomena in terms of density and sinking and floating. Weaving these concepts back to the Lava Lamp phenomenon allows students to feel a sense of accomplishment. They also determine a new set of questions for further investigation: How does the same object or substance both float and sink?

Note: Students have already seen that liquids can float and sink in other liquids. This lesson focuses on how density relates to the sinking and floating of solids. The lesson has three parts and will take more than one class period.

The amount of time the lesson takes will depend on how much explanation and class discussion you incorporate into the demonstrations and student activity. Practicing the demonstrations and activity before conducting the lesson is recommended.

**What Students Do**

**Part 1:** Students view a demonstration showing that a wax candle is heavier than a piece of clay. But they see that the heavier candle floats while the lighter piece of clay sinks. The class analyzes the density of wax, water, and clay for an explanation.

**Part 2:** Students view two demonstrations. The first shows that a wax candle floats in water while an identical candle sinks in alcohol. The second demonstration compares the mass of equal volumes of water and alcohol to show that alcohol is less dense than water and can explain the sinking of the candle in the alcohol.

**Part 3:** Students conduct an activity and see that a carrot slice sinks in fresh water. Students then dissolve salt in the water until the carrot slice floats. The class analyzes the change in the density from fresh to salt water which caused the carrot to float.

**What Students Learn**

* + An object that is less dense than water, floats in water.
	+ An object that is more dense than water, sinks in water.
	+ The density of water can be increased by dissolving salt into it.

**Materials & Preparation:**

**Part 1**

**Materials**

* DQB
* Water
* Float and Sink Lava Lamp Handout
* 2 tea light candles
* Large balance
* Clay
* Clear plastic container
* Water
* Isopropyl alcohol (90% or higher is recommended)
* Carrot slices
* Salt

**Part 2**

**Materials**

* + Balance
	+ Isopropyl alcohol, 70% or higher
	+ Water
	+ Graduated cylinder
	+ 2 identical tall clear plastic cups
	+ 2 tea light candles (Removed from their metal containers)

**Teacher preparation**

* + Use a graduated cylinder to measure 50 mL of water and pour it into a clear plastic cup.
	+ Measure 50 mL of isopropyl alcohol and pour it into another identical clear plastic cup.

**Part 3**

**Materials**

* + Tall clear plastic cup
	+ Water
	+ Carrot slice about ¼ inch thick
	+ Salt
	+ Spoon

**ENGAGE**

Tell students that even though density is a useful property for identifying substances, they won’t be able to use density to discover exactly what the substances are in the Lava Lamp.

But a better understanding of density and how it relates to sinking and floating will definitely help students discover and explain the Lava Lamp phenomena.

Students will also develop a "rule" about density for predicting whether an object will sink or float. They will also investigate how changing a liquid can influence whether an object will float or sink in that liquid.

**Part 1**

(From Middle School Chemistry - Chapter 3, Lesson 4)

1. **Start with a demonstration showing that an object which is heavy can float while an object which is light can sink.**

**Materials for the demonstration**

* + 2 tea light candles in their metal containers
	+ Clay
	+ Water in cup
	+ Small balance
	+ Tape
	+ Dropper

**Teacher preparation**

* + Use a small enough piece of clay so that you are sure that the candle weighs more than the clay.
	+ Pour water into a clear plastic container (or large cup) until it is about ½-full.

**EVALUATE**

1. **Hand out the Student Activity Sheet for Part 1 and conduct the demonstration.**

Give each student an activity sheet. The activity sheet will serve as the “Evaluate” component of each 5-E lesson plan. The activity sheets are formative assessments of student progress and understanding.

**Procedure**

* 1. Place a piece of clay that weighs less than a tea light candle on one end of a balance.
	2. Remove the candle from its metal container and place the candle on the other end of the balance.
	3. Ask students which is heavier, the clay or the candle. Ask them to predict which will sink and which will float.

4. Place the clay and candle in a clear container of water.

**Expected results**

Even though the candle weighs more than the clay, the candle floats, and the clay sinks.

**EXPLORE**

1. **Do a demonstration to compare the density of water, wax, and clay.**

**Procedure**

*Compare the density of wax and water*

* 1. Roll two pieces of tape and stick them to the center of the pan at each end of the balance.
	2. Attach each tea light candle to the tape so that each candle is in the center of the pan.
1. Use the wick to pull one candle out of its container.
2. Carefully pour water into the empty metal container until it fills the container to the same level as the candle in the other container. You may use a dropper to add the last bit of water and prevent spilling. The goal is to compare the mass of equal volumes of wax and water.

**Expected results**

The water has a greater mass than an equal volume of wax. So, the density of water must be greater than the density of wax.

**Ask students:**

* **Which weighs more, wax or an equal volume of water?**

Water weighs more than an equal volume of wax.

* **Which is more dense, wax or water?**

Water is more dense.

If students have trouble understanding this relationship between the mass and density of equal volumes, have them think about the demonstration from Lesson 5 with the aluminum and copper cubes. Both had the same volume, but the copper cube weighed more. Because the copper had more mass in the same volume, it also had a greater density.

**Procedure**

*Compare the density of clay and water*

* + 1. Make sure you have one piece of tape in the center of each pan on the balance.
		2. Fill one container with clay and place it on the tape so that it is in the center of the pan.
		3. Place an empty container on the tape at the opposite end of the balance.
		4. Slowly and carefully add water to the empty container until it is full.

**Expected results**

The clay has a greater mass than an equal volume of water. So, the density of clay is greater than the density of water.

**Ask students:**

* **Which weighs more, the clay or an equal volume of water?**

The clay weighs more than an equal volume of water.

* **Which is more dense, clay or water?**

Clay is more dense.

Explain to students that knowing the density of an object can help predict if it will sink or float in water.

**If an object is more dense than water, would you expect it to sink or float?**

Objects that are more dense than water sink.

**If an object is less dense than water, would you expect it to sink or float?**

Objects that are less dense than water float.

**EXPLAIN**

**3. Compare the density of wax, water, and clay on the molecular level to explain their different densities and why wax floats and clay sinks.**

Project the image ***Wax***.
[www.acs.org/middleschoolchemistry/simulations/chapter3/lesson4.html](http://www.acs.org/middleschoolchemistry/simulations/chapter3/lesson4.html)

Wax is made of carbon and hydrogen atoms connected together in long chains. These long chains are tangled and intertwined and packed together to make the wax.

[Project the image ***Water***.](https://www.middleschoolchemistry.com/multimedia/chapter3/lesson4#water)
[www.acs.org/middleschoolchemistry/simulations/chapter3/lesson4.html](http://www.acs.org/middleschoolchemistry/simulations/chapter3/lesson4.html)

Even though they both have lots of hydrogen atoms, water is more dense than wax because the oxygen in water is heavier and smaller than the carbon in the wax. Also, the long chains of the wax do not pack as efficiently as the small water molecules.

Project the image ***Clay***.
[www.acs.org/middleschoolchemistry/simulations/chapter3/lesson4.html](http://www.acs.org/middleschoolchemistry/simulations/chapter3/lesson4.html)

Clay has oxygen atoms like water, but it also has heavier atoms like silicon and aluminum. The oxygen atoms are bonded to the silicon and aluminum to make molecules with a lot of mass. These are packed closely together, which makes the clay more dense than water.

**EVALUATE**

**4. Remind students that they have seen that water has a density of 1 g/cm3 and then have them fill in the chart on the Student Activity Sheet.**

Have a class discussion about why an orange with the peel on floats while an orange without the peel sinks.

**Ask Students:**

* **What does this tell you about the density of the orange peel?**

The density of the orange peel must be less than 1 g/cm3. In fact, it must have a low enough density to make the entire orange, including the inside and the peel float.

* **In what way is the orange peel like a life jacket for the orange?**

A life jacket must have a low enough density so that it can make a person plus the life jacket float.

**Part 2**

**1. Give each student an Activity Sheet for Part 2 and do two demonstrations to show that the different densities of water and alcohol can explain a floating and sinking phenomena.**

(From Middle School Chemistry, Chapter 3, Lesson 5)

 **Materials**

* + Balance
	+ Isopropyl alcohol, 70% or higher
	+ Water
	+ Graduated cylinder
	+ 2 identical tall clear plastic cups
	+ 2 tea light candles (Removed from their metal containers)

**Teacher preparation**

* + Use a graduated cylinder to measure 50 mL of water and pour it into a clear plastic cup.
	+ Measure 50 mL of isopropyl alcohol and pour it into another identical clear plastic cup.

**Procedure**

* + 1. Place a tea light candle in a cup with water and another tea light candle in a cup with alcohol.

Alcohol

Water

* + 1. Hold up the two cups.

**Expected results**

The candle will float on water and sink in alcohol.

**Ask students:**

* **What might be causing one candle to float and the other to sink?**

Explain that the two candles are the same. Students should reason that the candle floats in water and sinks in alcohol because of the different densities of the liquids.

* **Does this experiment show that water and alcohol have the same or different densities?**

Students already know that water and alcohol have different densities from their calculations in Lesson 6. This demonstration gives them a chance to apply that knowledge to explain a new phenomenon.

Students should conclude that since the candle floats in water, water is *more* dense than wax. Since the candle sinks in alcohol, alcohol must be *less* dense than wax. Students should conclude that if water is more dense than wax and alcohol is less dense than wax, alcohol must be less dense than water.

**2. Show students another quick way of comparing the density of water and alcohol.**

**Procedure**

Demonstrate the density of water and alcohol by comparing the mass of equal volumes on a balance.

1. Remove the candles from each liquid and tell students that each cup contains the same volume of liquid.

2. Carefully place the cups of water and alcohol on opposite ends of a balance.

**Expected results**

The water will weigh more than the alcohol.

**EXPLAIN**

**3. Discuss how the simple test compares the density of the two liquids.**

Ask students:

* **Which liquid is more dense?**

Students should agree that the water is more dense than the alcohol.

* **How do you know?**

Since the water has more mass than an equal volume of alcohol, water must be more dense.

**4**. **If wax has a density of .95 g/cm3, invite students to explain why the wax floats in water and sinks in isopropyl alcohol.**

Wax floats in water (1.0 g/ml) because its density (.95 g/cm3) is less than the density of water. Wax sinks in isopropyl alcohol because its density is greater than the density of the alcohol (0.78 g/ml).

 **Model a substance being more or less dense.**

Consider a storytelling strategy to help students model density and its relationship to floating and sinking. Ask students to raise their hands in the air, ready to catch a stage diving Rockstar. You could even jump up on the table and pretend to be said rockstar. Ask students, “What would they need to do to ensure that the rockstar is held above the crowd?” Expected answer: they would have to be more packed together, giving them more mass per unit volume, or more become more dense. Ask, “What would happen if the spectators in the crowd were too far apart and had less mass per unit volume?” Expected answer: the rockstar would SINK!

**5. Have students revise their Lava Lamp model by incorporating ideas about density**

Have students revisit their Lava Lamp model. They should now explain, in terms of density, what they think is the difference between the blobs that rise to the top of the lamp compared to those that sink.

Students should realize that the blobs that rise are less dense than the liquid in the Lava Lamp, and the blobs that fall are more dense.

**Note:** At this point, no attempt is made to explain how heating affects the density of the blobs. This behavior will be explored in the next two lessons about heat transfer and temperature’s effect on the density of matter.

Models should use circles or dots to represent density - dots placed closer together model a more dense substance (blobs at the bottom of the lamp) while dots placed further apart represent the same substance when it is less dense (blobs at the top of the lamp). Students will return to this model several times during the unit as a way to visualize density.

**EXTEND**

Ask students

* **What do you know about the density of the blobs at the bottom of the lamp compared to the density of the liquid in the lamp.**

The blobs at the bottom are more dense than the liquid.

* **What do you know about the density of the blobs at the top of the lamp compared to the density of the liquid in the lamp.**

The blobs at the top are less dense than the liquid.

**Part 3**

1. **Give students an Activity Sheet for Part 3, and have students investigate a carrot slice in fresh and salt water.**

You may choose to do the following either as an activity that students do or as a demonstration.

Show how an object that sinks can be made to float if you increase the density of the water it is placed in.

**Materials**

* + Tall clear plastic cup
	+ Water
	+ Carrot slice about ¼ inch thick
	+ Salt
	+ Spoon

**Procedure**

1. Pour water into a clear tall plastic cup until it is about ½-filled.

2. Place a slice of carrot in the water. The carrot slice should sink.

Ask students:

* **Is the carrot more or less dense than the water?**Since the carrot sinks, students should conclude that the carrot is more dense than water.

3. Add about 1 teaspoon of salt to the water and stir.

4. Continue to stir until the carrot floats to the surface of the salt water. If the carrot does not float to the surface, add more salt and stir.

**Expected results**

The slice of carrot should rise and float in the saltwater.

Ask students:

* **Is the carrot more or less dense than saltwater?**

Since the carrot floats in saltwater, students should conclude that the carrot is less dense than saltwater.

* **How does adding salt change the density of the water?**

Dissolving salt in water increases both the mass and volume of the water, but it increases the mass a lot more. Because D = m/v, increasing the mass more than the volume results in an increase in density.

* **What would you expect if you placed equal volumes of water and saltwater on opposite ends of a balance?**

If equal volumes of water and saltwater were placed on a balance, the saltwater would be heavier.

Summarize that to make a substance sink and then rise, something had to change. In the case with the carrot, we changed the mass of the water, by adding more stuff, to the same volume.

Remind students that volume is the space that matter takes up and mass is the amount of matter in an object.

**2. Guide a discussion about the Lava Lamp:**

What do you think is changing about the blobs when they rise and sink in the Lava Lamp? Remind students that we are NOT adding *anything* to the liquid in the Lava Lamp. This Lava Lamp is a closed system - no mass leaves or enters the lamp.

Invite students to use Talk Moves to discuss initial ideas of this mystery within the Lava Lamp. Possible questions could include: Does the amount of matter change when we heat it up? Does the volume of anything change? Would the density change?

For the blobs in the Lava Lamp to sometimes float and sometimes sink, something must be changing. Could it be the changing density of the liquid in the Lava Lamp, or the changing density of the blobs?

Students need to settle on the idea that something about the blobs is changing. If the mass isn't changing, then the volume probably is. Students should at this point determine that the heat changes something about the volume of the blobs. (It's not important at this time that they understand *how* volume changes with heat--as that is what you'll explore in later lessons. But you do want to guide students to think about volume changing, and thus density changing.)

Students will eventually see that the effect of heat on density is the key to understanding how the Lava Lamp works. Students will begin that exploration in the next lesson on **kinetic energy**.