How does the Density of a Liquid Affect the Buoyancy of an Object?
A Lesson on Density and Buoyancy

Jennifer Olesh
East Washington Middle School
Pekin, IN

Lesson #15

Edited by Melvin Limson, Margaret Shain, and Marsha Lakes Matyas

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Note: The activities that follow are DRAFT activities and have not yet been peer reviewed for content accuracy or pedagogy. The lesson plans and opinions in this report are those of the authors and do not necessarily reflect the opinions of any of the supporting institutions or the editors.
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References

Alignment and references to state science education standards as of 2010 are cited by the authors.
How Does the Density of a Liquid affect the Buoyancy of an Object? A Lesson on Density and Buoyancy

PURPOSE
The overall purpose of this activity is to investigate how the density of a liquid affects the buoyancy of certain objects.

OBJECTIVES
Upon completion of this activity, students will be able to:
• relate density and buoyancy.
• predict, when shown, if objects will float or sink.
• determine, when given examples, if the buoyant force will cause the object to float or sink.
• list three daily life examples where the density of a material affects the buoyancy of an object.

GRADE LEVEL
7th and 8th grade although it could be adapted for high school

PRIOR KNOWLEDGE
• Students should already be familiar with the calculation of density of regularly and irregularly shaped objects.
• Students should also be familiar with how to use measuring tools such as a graduated cylinder, a balance and a ruler or meter stick. If an electronic balance is used for the clay boats, it might be necessary to instruct students on the use of the electronic balance.

TIME REQUIRED
8-9 class periods (50 minutes each) as described here:
• 1 class period for the discrepant event and KWL
• 2 class periods for the web quest
• 1 class period for the aluminum foil/clay activity
• 4 class periods for the design, construction and testing of the clay boats and preparing the class presentation
• 1 class period for students to share their findings

INCLUDING ALL STUDENTS
• Students will choose a partner for the activity.
• Extension activities present issues that are current (e.g., Gulf Oil Spill of 2010) as well as other “real life” experiences.
• The model building will appeal to the tactile learner.
• Final project will highlight visual, auditory and written modalities with students making a poster or PowerPoint presentations. They will also be presenting their project in front of the class. The artistic student will have an opportunity to use their talents for this portion of the project.
• Problem solving is highlighted in this activity when students manipulate the size and shape of the clay boat, and the type of liquid that they are using.

QUESTIONS TO ASK ALONG THE WAY
• Does the density of the clay change as the shape changes?
• How do buoyancy and density relate?
• Would ship builders need to know if they were building a ship for salt or fresh water? Why?
• In nature, where can we see the concept of buoyancy? Why is it important?
• How is this concept used in the clean up of the Gulf of Mexico oil spill of 2010?
How Does the Density of a Liquid affect the Buoyancy of an Object?

A Lesson on Density and Buoyancy

**Teacher Section**

**NATIONAL SCIENCE EDUCATION STANDARDS**

<table>
<thead>
<tr>
<th>K-12 Unifying Concepts and Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence, models and explanation</td>
</tr>
<tr>
<td>Change, constancy and measurement</td>
</tr>
</tbody>
</table>

Grades 5-8

**Science as Inquiry**

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

**Physical Science**

- Properties and changes of properties in matter
- Motions and forces

**Science and Technology**

- Abilities of technical design
- Understanding about technical design

**INDIANA STATE SCIENCE EDUCATION STANDARDS**

- Make predictions and develop testable questions based on research and prior knowledge.
- Plan and carry out investigations as a class, in small groups or independently often over a period of several class lessons.
- Incorporate variables that can be changed, measured or controlled.
- Test predictions with multiple trials
- Keep accurate records in a notebook during investigations.
- Communicate findings using graphs, charts, maps and models through oral and written reports.
- Document the design throughout the entire design process so that it can be replicated in a portfolio/notebook with drawings including labels.
- Test and evaluate how well the solution meets the goal.
- Evaluate and test the design using measurement.
- Present evidence using mathematical representations (graphs, data tables).

6.3.20 Investigate that equal volumes of different substances usually have different masses as well as different densities.

7.1.6 Explain that forces have magnitude and direction and those forces can be added to determine the net force acting on an object.

7.1.7 Explain how engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems

C.1.7 Define density and distinguish among materials based on densities. Perform calculations involving density.

CP.1.22 Recognize and explain that whenever one object exerts a force on another, an equal and opposite force is exerted back on it by the other object.

P.1.2 Measure or determine the physical quantities including mass, charge, pressure, volume, temperature, and density of an object or unknown sample.
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MATERIALS
Include the following materials in a large tub per student pair:
- 30 cm of aluminum foil/50 g of clay
- metal washers
- 125 g of clay
- balance (electronic or triple beam will work) to mass the washers after each trial.
- ruler or meter stick for measuring the dimensions of the boat

For floating the clay boat:
- water
- 70% isopropyl alcohol
- 10% salt water solution
- 1 L of corn oil
- 1 L of syrup
- 1 L of dishwashing liquid

Teacher Preparation
- Mass the clay in advance-students will need two samples, one 50g sample for the aluminum foil/clay activity and one 125g sample for the boat activity.
- 10% salt water solution can be made with regular table salt.

SAFETY
- Normal classroom safety procedures (no running, work at lab table).
- There are no special safety concerns with this lab.
- Students should wash their hands after handling the clay.
- As with any lab situation, students should not eat or drink any materials or use any lab supplies as dishes or cups.

PREPARATION AND PROCEDURE

Step 1: Capturing the Student’s Interest
- Materials for this step: 2 large aquariums or similar glass containers, water, 70% isopropyl alcohol, can of Diet Coke and can of regular Coke.
- Begin the activity with a discrepant event. When students enter the classroom, have an aquarium filled with water. Have a can of Coke and a can of Diet Coke in the aquarium. The Coke will sink and the Diet Coke will float. Have students write down observations/hypotheses as to why this happens. Then, move the cans from the aquarium with water into an aquarium filled to the same level with the alcohol. Both cans will sink. Don’t tell the students what changed. Have them record their observations/hypotheses. **Note to the Teacher: Check the cans before you show this activity to the class. Sometimes due to differences in the can contents the diet coke will not float or the regular coke will. You may have to try a few before you get the correct combination.**

Step 2: Begin the KWL
- KWL on Buoyancy – have students complete K and W part of the KWL on buoyancy. Give them 10 min. on their own and then 10 min with a partner to discuss and write down their thoughts. Then as a class, discuss their K and W. The students will keep these papers until the end of the lesson. At that time they will complete (on their own) the L and turn the paper in. Give the students time to work alone and then with a partner before the discussion to let them have something down on paper. Another way to do this would be as a group discussion only but still give the students a few minutes to put something on paper. In this way they will be able to contribute better to a class discussion.
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**PREPARATION AND PROCEDURE**

**Step 3: Students Complete a Web Quest on Buoyancy and Density**
- Use the questions and websites listed in the Web Quest. Students will work in pairs. They can divide the questions or both look for the same answer and compare. The web quest will be turned in and checked by the teacher before students proceed to the foil/clay activity.

**Step 4: Students Experiment with the Aluminum Foil/Clay Activity**
- Give students one 30 cm long piece of aluminum foil and one 50 g piece of clay. Students find the mass of the foil. Ask students if the piece of foil will float or sink. Students place the foil in water and see what happens. Ask students if changing the size of the foil will change the mass. Students crumple the foil and re-mass. Ask students how this will affect the foil with respect to floating or sinking, and have students experiment. Students can then repeat activity with the clay.

**Step 5: Clay Boat Activity**
- Students propose a hypothesis stating the liquid type and boat design that will float the most mass.
- Students will design and test clay boats. The students will use different types of liquid to find the boat design and liquid combination that will hold the most mass. The students will be given water, 10% salt water, isopropyl alcohol, dishwashing liquid, corn syrup and cooking oil. Students will then present their findings to the class. The findings can be presented in the form of a poster, video or PowerPoint presentation. The presentation should highlight the design process, the trials, and the final outcome.

**WHERE TO GO FROM HERE**

**Follow up activities**
- Have students investigate the Gulf of Mexico oil spill. How did the clean up relate to the study of buoyancy and density?
- Have a scuba diver talk to the class. How is the preparation for a dive different if diving in salt or fresh water?
- How could this lesson be related to submarines?
- Are there any examples of buoyancy in nature?
- Can the principles used in liquids be applied to air? (The term “fluid” could be introduced here if it has not already been covered).

**SUGGESTIONS FOR ASSESSMENT**
- Hypothesis and experimental design
- Data chart showing trials and revisions
- Presentation showing final outcome and model (rubric in Student Section)
- Web Quest
- The “L” section of the KWL

Jennifer Olesh
Pekin, IN

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1. Archimede’s Principle
   www.aquaholic.com/gasses/archem.htm
   A website that is actually sponsored by a diving company. It covers Archimede’s Principle and also talks about the differences between diving in salt and fresh water. Accessed August 25, 2010.

2. Archimede’s Principle

3. Buoyancy
   http://hyperphysics.phy-astr.gsu.edu/hbase/pbuoy.html

4. Buoyancy Game Show
   www.surfnetkids.com/games/quiz/buoyancy

5. How Submarines Work
   http://science.howstuffworks.com/transport/engines-equipment/submarine1.htm

6. Nova: Voyage of Doom
   http://www.pbs.org/wgbh/nova/lasalle/
   A companion website to the Nova Program. Highlights the shipwreck as well as a “hot science” section on Buoyancy Brainteasers. Accessed on August 20, 2010.

7. Sinking and Floating Soda Cans
   http://scifun.chem.wisc.edu/homeexpts/cans.htm
Web Quest: Buoyancy, Density and Archimedes’ Principle!

- Listed below are several questions to research as we begin our unit on buoyancy and density. The included websites can be used to answer the questions listed below. However, search engines such as Google and Bing may also be used to find information. Please remember to consider the source of the website when searching. Edu and .org websites are usually reliable. Use the Internet Treasure Hunt Worksheet with a question and use two websites to compare and contrast the information. Ask for help if necessary! Also, don’t be limited to the questions below. Explore the website for more information if it looks good.
- Work with a partner to answer the questions. Divide up the questions or work on one question together. Use your own words to answer the questions. Two class periods will be used to finish the web quest. It may be completed at home if for some reason a group does not finish in class.

Questions:
1. What is density?
2. How is density calculated? Is there more than one way?? Explain.
3. Who was Archimedes?
4. What is Archimedes’ Principle? Don’t just copy down the definition-explain it!
5. How does Archimedes’ Principle relate to buoyancy and density?
6. Why is it easier to float in the ocean than in fresh water?
7. Why might a ship builder need to understand density and buoyancy?
8. Why can a ship float but a dime sink?
9. Where in nature can you find an example of an animal that uses buoyancy?
10. Look up each of these salty bodies of water: The Dead Sea, The Great Salt Lake, and Lake Mono.
   a. Why is the body of water so salty?
   b. How does the density of the water compare to the ocean?
   c. How would a boat float differently in this body of water and in one of the Great Lakes?

Websites:

http://www.pbs.org/wgbh/nova/lasalle
http://www.surfnetkids.com/games/quiz/buoyancy/
http://physics.suite101.com/article.cfm/archimedess_principle
http://hyperphysics.phy-astr.gsu.edu/HBASE/pbuoy.html
http://www.aquaholic.com/gasses/archem.htm
http://science.howstuffworks.com/transport/engines-equipment/submarine1.htm
INTERNET TREASURE HUNT WORKSHEET
This web info search will help you find information about a particular question on density and buoyancy. You will be looking at pre-selected web sites to answer each question. It is important to not only find the information at the site, but also to consider who wrote the site, what their purpose is in writing it, and how credible (accurate) you think the information is.

<table>
<thead>
<tr>
<th>Question:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Website Title URL</td>
</tr>
<tr>
<td>Who created this website (organization, etc.)?</td>
</tr>
<tr>
<td>Why did they create it? (check all that apply)</td>
</tr>
<tr>
<td>☐ To influence the reader’s opinion</td>
</tr>
<tr>
<td>☐ To sell a product or service</td>
</tr>
<tr>
<td>☐ I’m not sure</td>
</tr>
<tr>
<td>How credible (accurate) do you think the info is?</td>
</tr>
<tr>
<td>☐ Somewhat accurate</td>
</tr>
<tr>
<td>☐ Not very accurate</td>
</tr>
<tr>
<td>☐ I’m not sure</td>
</tr>
<tr>
<td>What did you learn?</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
</tbody>
</table>

STUDENT INSTRUCTIONS

Part 1: Aluminum Foil Boat/Clay Boat
Obtain a 30 cm piece of aluminum foil and a 50 g piece of clay. Answer the questions below.

1. What is the mass in grams of the foil? ______________
2. If the foil is placed in a pan of water, will it float or sink? ______________
3. Try it and record what happens. ______________
4. Dry the foil off before continuing.
5. If the foil is crumpled into a ball, what will happen to its mass? __________
6. Crumple the aluminum foil into a ball and record the mass. __________
7. Compare the mass of the foil crumpled and un-crumpled.
8. Will the crumpled piece of aluminum foil float or sink? _______________
9. Try it and record what happens.

Next, obtain a 50 g piece of clay from your teacher. Repeat the steps above using clay instead of aluminum foil. Record your observations.

With your partner, start thinking about how what happened with the foil and clay could be extended to other materials. You will use these thoughts as you begin Part 2.
Part 2: Clay Boats

1. Each pair of students will be given 125 g of clay and access to metal washers.
2. Each pair of will be given access to 6 different liquids: water, 70% isopropyl alcohol, corn syrup, cooking oil, dishwashing liquid, and a 10% salt water solution.
3. You should first propose a hypothesis. The hypothesis should state what type of liquid and what boat design will allow the most mass to be floated. The statement should be listed in the presentation.
4. Using the 125 g of clay and the different liquids, You should come up with the best combination of liquid and boat design that will hold the largest mass of metal washers.
5. Keep track of the design and trials using the format below. The testing documentation must be turned in with your final project.
6. The final project will consist of some type of presentation to the class. This can be in the form of a video, power point or poster. You must show trials which combined different liquids and different boat designs.
7. Reference at least two of the sources that were used in other activities this week in the final presentation. This can be things learned from the websites, the web quest, the class discussion or the aluminum foil/clay activity.
8. Remember, keep track of trials and write down why certain things were tried by the pair!
9. The project will last for four days. During this time you will design, test and record results and put together a presentation for the class showing testing and results.
## DENSITY and BUOYANCY

<table>
<thead>
<tr>
<th>What I Know about this topic/question</th>
<th>What I Want to Know about this topic/question</th>
<th>What I Learned about this topic/question</th>
</tr>
</thead>
</table>

### Topic of Discussion:

**KWUL**

- **K**nowledge: what I already know about this topic.
- **W**hat I **W**ant: what I want to know about this topic.
- **L**earned: what I learned about this topic.

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### How does the Density of a Liquid affect the Buoyancy of an Object?

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<table>
<thead>
<tr>
<th>Trial #</th>
<th>Liquid</th>
<th>Mass of washers</th>
<th>Design (sketch, picture or dimensions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
### Grading Rubric

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scientific Knowledge</strong></td>
<td>Explanations by all group members indicate a clear and accurate understanding of scientific principles underlying the construction and modifications.</td>
<td>Explanations by all group members indicate a relatively accurate understanding of scientific principles underlying the construction and modifications.</td>
<td>Explanations by most group members indicate relatively accurate understanding of scientific principles underlying the construction and modifications.</td>
<td>Explanations by several members of the group do not illustrate much understanding of scientific principles underlying the construction and modifications.</td>
</tr>
<tr>
<td><strong>Information Gathering</strong></td>
<td>Accurate information taken from several sources in a systematic manner.</td>
<td>Accurate information taken from a couple of sources in a systematic manner.</td>
<td>Accurate information taken from a couple of sources but not systematically.</td>
<td>Information taken from only one source and/or information not accurate.</td>
</tr>
<tr>
<td><strong>Construction: Materials</strong></td>
<td>Appropriate materials were selected and creatively modified in ways that made them even better.</td>
<td>Appropriate materials were selected and there was an attempt at creative modification to make them even better.</td>
<td>Appropriate materials were selected.</td>
<td>Inappropriate materials were selected and contributed to a product that performed poorly.</td>
</tr>
<tr>
<td><strong>Construction: Care Taken</strong></td>
<td>Great care taken in construction process so that the structure is neat, attractive and follows plans accurately.</td>
<td>Construction was careful and accurate for the most part, but 1-2 details could have been refined for a more attractive product.</td>
<td>Construction accurately followed the plans, but 3-4 details could have been refined for a more attractive product.</td>
<td>Construction appears careless or haphazard. Many details need refinement for a strong or attractive product.</td>
</tr>
<tr>
<td><strong>Data Collection</strong></td>
<td>Data taken several times in a careful, reliable manner.</td>
<td>Data taken twice in a careful, reliable manner.</td>
<td>Data taken once in a careful, reliable manner.</td>
<td>Data not taken carefully OR not taken in a reliable manner.</td>
</tr>
<tr>
<td><strong>Modification/Testing</strong></td>
<td>Clear evidence of troubleshooting, testing, and refinements based on data or scientific principles.</td>
<td>Clear evidence of troubleshooting, testing and refinements.</td>
<td>Some evidence of troubleshooting, testing and refinements.</td>
<td>Little evidence of troubleshooting, testing or refinement.</td>
</tr>
<tr>
<td><strong>Presentation of Final Project</strong></td>
<td>Final project shows a clear understanding of the topic as well as illustrating the design process</td>
<td>The final project shows an understanding of the topic but does not illustrate the design process</td>
<td>The final project shows the design process but there are errors in the understanding of the topic</td>
<td>Neither the topic nor the design process are correct</td>
</tr>
</tbody>
</table>

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