Science

Physical Science

Grade 8

Lesson Plans

“The Buoyancy Challenge!”

Subject:
Science: Physical Science

Level:
Grade 8

Abstract:

Through a series of activities students will develop their understanding of key concepts related to buoyancy, including the force of gravity, mass and weight, volume, and density. They will then apply their knowledge to explore and test buoyancy concepts.

As students begin to understand the fundamental relationships of these key concepts, they will be asked to predict the density of a number of common objects and whether they will float or sink in water. In order to be able to calculate the density of these common objects, students will next measure each object’s mass and volume. They will then calculate each object’s density and test their predictions of whether the objects will float or sink.

The “buoyancy challenge” for students will be to see if they can alter an object to make it sink when it would not sink originally or to make an object float when it sank originally. Students must explain what they changed and how these changes resulted in a different outcome.

Lesson activities are presented through handouts. Students will be learning and applying formulas to make calculations throughout the lesson. When asked to perform and record manual calculations, students will use a worksheet corresponding to the handout. A “Buoyancy Workbook” template is also provided. Each student can use a copy of this template to record and maintain designated data for the duration of this lesson, and to create formulas that perform automatic calculations on entered data.

Finally, each student will complete the lesson by writing a report in Word that incorporates his or her data, observations, and an explanation of why certain objects float while other objects sink.

Invitation:

Why is it that a block of wood can float while a similarly sized block of concrete can be used as an anchor? Why do people float so easily in seawater but not as easily in fresh water?

How come an astronaut can jump so much higher and farther on the moon than on Earth? Why do astronauts weigh less on the moon than on Earth? How do mass and weight differ on Earth and on the moon?

Why does a hot air balloon rise when filled with warm air but fall when filled with cool air? Why does ice float on top of a soda? Why do icebergs float on the surface of the ocean?

In this lesson, you will discover the scientific concepts that provide the answers to these questions. Applying these concepts, you will be able to understand and explain other related conditions, for example, why water vapor rises while rain falls, how the tectonic plates of the earth are powered by rising and falling magma from the earth's mantle, even how central heating systems operate.

Situations:

Where:

The lesson will take place at school in the classroom or science laboratory and will be finished in the computer lab. Some report work may take place outside the school if students have access to a computer

When: This lesson will take place during Science class. This lesson can also be integrated with a math class, such as pre-Algebra or Algebra. This lesson could precede a unit on climate and weather, heat flow, ocean ecology, deep ocean circulation systems, or plate tectonics.

How Long:

This lesson will require from one week to two weeks to complete.

Tasks:

Task 1: Use the Invitation to open the lesson and provide an overview of lesson activities. Emphasize the progressive nature of the lesson, how learned concepts will be applied to a final challenge.

Distribute both the "Handout: Calculating the Force of Gravity" and the "Worksheet: Manually Calculating the Force of Gravity" attachments and guide students through the activities. By completing these activities, students will understand key gravity concepts, namely:

- Gravity exists between any two objects that have mass.
- As mass increases the force of gravity increases in a linear fashion.

- As the distance between two objects of mass decreases, the force of gravity between the two objects increases logarithmically.
- The Inverse Square Law (the force of gravity is inversely related to the square of the distance between two objects).
- Why the force of gravity is less on the moon than on Earth.

Students will also be able to apply the formula for calculating the relative force of gravity between objects applying different variables of mass and distance. This lesson prepares students to understand the difference between mass and weight in order to eventually calculate the density of different objects.

Review the equation for calculating the force of gravity. Have students complete the three provided examples on the worksheet and review. (The additional examples can be completed in class or as homework.)

Next, guide students through step 2 on the “Handout: Calculating the Force of Gravity” attachment. (See the “Sample: Buoyancy Workbook” attachment. The “Template: Buoyancy Workbook” attachment is provided for students to use to do their electronic calculations.) If necessary, use the “Template: Buoyancy Workbook” attachment to demonstrate how to create a table with formula for calculating the force of gravity. Provide assistance creating the tables in this activity as needed.

Use the questions on the handout sheet as prompts to facilitate class discussion at appropriate times. Review the results of their calculations and their related conclusions. During the discussion on astronauts, if desired, show students film clips (see Lesson Resources) of astronauts leaving for space, working in space, and walking on the moon.

Student calculations and conclusions should reflect that as the distance (d) between an astronaut and a planet increases, the force of gravity decreases exponentially, and vice-versa. Students should be able to note which variables remained constant and which changed for any particular calculation.

The answer for when the force of gravity is being exerted equally on the astronaut by Earth and the moon can be estimated by graphing Fg of Earth exerted on the astronaut, which decreases as he travels to the moon. On the same graph, calculate Fg of the moon on the astronaut, which increases as the astronaut travels to the moon. The point where the graphs intersect is the point of equal gravitational force exerted upon the astronaut by both planets. Finally, to answer the Bonus Question, astronauts can return home

when the force of their spacecraft flying away from the moon is greater then the force of gravity pulling them back towards the moon.

Task 2:
This task focuses on concepts related to mass and weight. You can choose whether to have students complete massing activities using the “Handout: Measuring the Mass and Weight of Objects” and the “Worksheet: Measuring the Mass and Weight of Objects” attachments or the “Sample: Buoyancy Workbook” attachment. If you use the worksheet, you need only distribute it and NOT the handout; conversely, if you use the “Buoyancy Workbook” you need only distribute the handout and not the worksheet.

Before distributing the handout or worksheet on mass and weight to your students, conduct an initial discussion on these concepts. Determine whether students know the definitions and differences between these concepts, including how each is measured. Introduce the units of mass if the students are not familiar with them. (See the “Handout: The Metric System” attachment.)

This activity presents definitions of mass and weight and requires students to estimate then measure the mass of some common objects. By completing this activity, students will understand that:

- Mass refers to the amount of matter an object contains.
- Mass is measured in grams and can be converted to orders of 10 in the metric system.
- Weight refers to how strongly gravity pulls on an object.
- Weight is measured on a scale.
- While an object’s weight can change with location, an object's mass remains constant across various locations.

Students will estimate the mass of some common objects in the room. If students are unfamiliar with using a balance to measure mass, a demonstration will be necessary. Students will review data from the previous activity and be able to state how, if at all, mass and weight change for the astronaut on Earth and on the moon, and if so, why.

Task 3:
Guide students through the “Handout: Measuring the Volume of Liquids” attachment. By completing this activity, students will understand that:

- Volume refers to the amount of space an object occupies.
- Volume is measured using the metric system (milliliters, liters).

- Different tools can be used to measure the volume of liquid, and provide varying levels of accuracy.
- The relationship of mass and volume (mass/volume) = density.

Students will also be able to demonstrate the ability to measure the volume of liquids using calibrated beakers, graduated cylinders. and pipettes.

Before beginning this activity, ensure that you have the proper supplies and equipment. Facilitate appropriate discussion during this activity, including one on the definition of volume.

If necessary, show students how to read a graduated cylinder and provide contextual information on key related topics such as surface tension, the meniscus, etc. A tip: reading graduated cylinders can be easier and more accurate if the reader holds a card behind the graduated cylinder.

As necessary, demonstrate the use of a range of pipettes for the students, including those needed for the activity. This section can be extended to include the use of micropipettes. These pipettes can measure down to 2/1000 of an ml. A thousandth of a milliliter is called a microliter. Micropipettes are available in the ranges of 200-1000 microliters, 200-20 microliters and 2-20 microliters. Refer students again to the “Handout: The Metric System” attachment. Students will recognize micropipettes from the forensic crime shows currently on popular television shows.

In this activity’s conclusion, when introducing the concept of density and how it is calculated, reinforce that the mass of water in grams equals the volume of water in milliliters.

Task 4:
Using the “Worksheet: Manually Calculating Density” attachment, students first calculate the density of different objects manually. Next they follow the instructions in the “Handout: Calculating Density” attachment to create a table and formula in their “Template: Buoyancy Workbook” that will automatically calculate object density. Finally, they use this table to auto-calculate the density for 10 objects with mass and volume variables provided.

Remind them that density is the ratio of mass to volume for an object, and that the calculation for determining density is mass divided by volume.

Task 5:
Guide students through the “Worksheet: Manually Calculating the Volume, Mass, and Density of Regularly Shaped Solid Objects” attachment. In this

activity, students will recall or be introduced to the mathematical formulas for calculating the volumes of regularly shaped solid objects. Then the students will manually calculate the volume for various objects using provided measurements. Next, using the “Handout: Measuring and Calculating the Volume, Mass, and Density of Regularly Shaped Solid Objects” attachment, students will create a series of tables in their “Template: Buoyancy Workbook” on the “Regularly Shaped Objects” worksheet. These tables will contain formulas for calculating the volume of regularly shaped objects. Students will then measure some objects and enter their measurements into the table. The volume calculations will then be automatically performed. Students will then add a column for “mass” to the table, mass the same objects, and enter the data into the appropriate cell for each object.

Finally, students will add a column for density to the table, and in the first cell directly below the density header, create the formula for calculating density (mass/volume) using the cells containing mass and volume data for the first object in each category (cubes, rectangles, cylinders, etc.). They will extend that formula to the other objects in each group. By completing this task, students will automatically obtain the density for objects they have measured and massed.

Reminder: It is important to measure the lengths, widths, heights, or radius of each object in the same units (meters, centimeters, millimeters, etc) and to know what units were used when comparing the densities of objects to the densities of different liquid mediums. You may need to point out that when comparing densities, it is necessary for all objects to be measured in the same or equivalent units, remembering that 1 cubic centimeter = 1 milliliter.

Task 6:
Guide students through the “Worksheet: Measuring and Calculating the Volume, Mass, and Density of Irregularly Shaped Solid Objects” attachment. This task is very similar to Task 5. The key difference is the way volume is measured (by displacement instead of measuring dimensions).

Provide the necessary supplies including graduated cylinders, calibrated beakers, and paper towels for drying objects. You will also need to provide irregularly shaped but common objects (pencils, peanut in shell, ring, bottle cap, necklace, earring, etc.). You may care or need to demonstrate the process. You may also care to demonstrate alternate ways of measuring using displacement. Some objects, for example, may not fit inside a graduated cylinder or calibrated beaker. In this case you can use a larger container, measure the starting volume of water in the container, submerge

the object and mark the new waterline. After removing the object, you can add a volume of water to bring the known volume of water to the new waterline. You can then subtract the original volume of water from the final volume of water to determine the volume of the object.

Assist students as they perform measurements and calculations, and as they use the “Handout: Measuring and Calculating the Volume, Mass, and Density of Irregularly Shaped Solid Objects” attachment to create and complete their latest table in the “Template: Buoyancy Workbook.”

Task 7:
Review the skills students have acquired so far in this lesson. Students by now are able to:

- Identify the units of measurements used in the metric system to measure mass, volume and length.
- Estimate the mass of an object accurately.
- Measure the mass of an object accurately.
- Measure the dimensions of a regularly shaped object.
- Measure the volume of an irregularly shaped object by displacement.
- Manually calculate the volume of a regularly shaped object.
- Manually calculate the density of a regularly shaped object.
- Set up tables in Excel.
- Format cells to perform automatic calculations in Excel.
- Automatically calculate the volume of a regularly shaped object.
- Automatically calculate the density of a regularly shaped object.
- Automatically calculate the density of an irregularly shaped object.

Next, guide students through the “Handout: Buoyancy” attachment. In this activity students will measure the density of water and some other common objects. Students will predict whether these objects will sink or float in the water by comparing their densities, recording their data and testing their predictions.

Either during this task or as part of Task 8, the Buoyancy Challenge, you can extend this activity to include other liquid media besides water. Remember, however, that different liquid media, whether oil, dish soap, or others, will have different densities, and will not likely have the 1:1 equivalency between volume and mass that water does. Use a beaker containing the liquid medium and a balance to measure the mass of the medium, then use that mass with the liquid medium’s volume to calculate its density before using it for this buoyancy activity.

Guide students through the creation of the new table on the “Buoyancy” worksheet in their “Template: Buoyancy Workbook.” If students truly understand the relationship between the density of an object and the density of water and the implications for whether that object will float or sink, they will be able to make accurate predictions.

Task 8:
In the “Handout: Buoyancy Challenge” attachment, students are challenged to see if they can change the density relationship between objects and water to achieve the opposite of their initial result. Observe, provide hints and assess how much the students understand about density. Students will be given an entire period to experiment with this puzzler.

Students can approach this problem in a number of ways. One approach would be to increase the density of the liquid medium by dissolving some substance into the water (such as salt). Students will need to calculate the new density of the medium after adding salt to the water. While this is challenging, it is a good test to see how much they understand about calculating the density of liquids. Another approach would be to decrease the mass of the object being tested without decreasing its volume. (This is analogous to lightening the load on a boat.) They could hollow out the solid object so its volume remains the same but its mass is decreased. (Note that cutting it up does not change its density, a fact that students may discover by trying this solution).

Allow students to try all solutions that are safe. Provide hints as appropriate as students attempt to solve the problem, and provoke discussion regarding particular strategies that students devise.

Students could also create or utilize different liquid media to put the common objects into, for example, liquid soap, vegetable oil, diet soda, regular soda and milk. Students would need to calculate the density of these liquids (using the balance method described in Task 7) and then predict if the objects will sink or float in each medium. Students could expand their “Buoyancy” worksheet to include additional columns of data and calculations for these other liquid media, and for additional cycles of predicting and testing with different objects and media. Students can then test their predictions.

Task 9:
To summarize what they've learned, students will create a final report. This final report can be generated from student worksheets, the “Template: Buoyancy Workbook” attachment, and student notes, which can be taken using your typical lab book process. Review the “Handout: Word Report”

attachment and the “Final Report Rubric” attachment with your students, guide them through an initial draft, and then collect their completed report. Encourage students to self evaluate their report and to peer edit the reports of their lab team and other students in the class. Encourage and support the inclusion of charts as appropriate and provide them with the “Step Sheet: Inserting Graphs from Excel” attachment and the “Step Sheet: Inserting Pictures” attachment.

Interactions:
Full Class: Students will work as an entire class when exploring each successive concept and when engaging in discussion on findings and results.

Partners: Students will work in teams or pairs to make and record the different measurements required in this lesson. Each student is responsible for making sure that the team is getting the correct information and using the measuring devices accurately and correctly. Team members are each responsible for the report at the end of the lesson but team members are encouraged to assist each other in gathering the data, creating the data tables, formatting the spreadsheets and creating the final report. Partners are asked to proofread each team member’s report for accuracy as well as any errors in grammar and spelling.

Individual: Each student will complete an individual final report.

Standards:
Focus on Physical Science
Grade 8
Density and Buoyancy
8. All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept:
a. *Students know* density is mass per unit volume.
b. *Students know* how to calculate the density of substances (regular and irregular solids and liquids) from measurements of mass and volume.
d. *Students know* how to predict whether an object will float or sink.

Focus on Life Science
Grade 7
Investigation and Experimentation
7. Scientific progress is made by asking meaningful questions and by conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

a. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
e. Communicate the steps and results from an investigation in written reports and oral presentations.

Assessment:

- Worksheets: use your preferred technique for correcting student worksheets (self-correction, peer exchange and correction, teacher correction, etc.).

- "Template: Buoyancy Workbook:" use your preferred correction method to assess student work for the tasks assigned through the handouts and completed in the "Template: Buoyancy Workbook," checking for correctly prepared tables, correctly constructed and implemented formulas, and correct quantitative answers. Alternately, you can modify the Final Report parameters to require each student to include evidence of correct work from their "Template: Buoyancy Workbook," including a list of formulas they created to conduct calculations.

- "Final Report Rubric:" use to assess student learning and work as expressed through their Final Report. Modify the report requirements and rubric as desired. The report should convey student understanding of key concepts.

Tools:

- Microsoft Excel
- Microsoft Word

Materials

- balances
- graduated cylinders (100 ml; 500 ml and 1000 ml)
- beakers (not calibrated)
- beakers (500 ml; 1000 ml)
- pipettes (10 ml; 1.0 ml; 0.1 ml; micro pipette)
- model of an atom
- regularly shaped solid objects (cube, sphere, cone, cylinder, rectangle)
- irregularly shaped solid objects (random classroom objects, e.g., pencils, jar lids, etc.)
- salt
- soda (diet)
- soda (sugar)
- milk
- vegetable Oil

- metric rulers

Project Tips and Alternatives:

Tip#1:

At the beginning of this lesson, frame how you want students to record their observations and notes. Use your typical lab book recording process. Each handout and worksheet contains key guiding questions. Students can include their responses and supporting evidence in the lab book and then in their final report.

Tip#2:

There are many applications of this unit to other content areas. Density differences create convection currents, which can be used in teaching about motion (Strand 1) and forces (Strand 2). Convection currents cause wind patterns, weather patterns and distribution of heat energy on earth and in buildings. All forces are trying to reach equilibrium and density differences play a role in the earth's energy systems as well as the movement of such things as magma to the earth's surface to create new crust and recycle old crust.

Tip#3:

Reinforce that students need to follow procedures for correctly using equipment and materials, so that nothing breaks and no one is put at risk of injury. If a student is unsure of what to do, they need to stop and ask a fellow student or the teacher.

Attachments/Handouts:

- "Handout: Calculating the Force of Gravity"
- "Worksheet: Manually Calculating the Force of Gravity"
- "Sample: Buoyancy Workbook"
- "Template: Buoyancy Workbook"
- "Handout: Measuring the Mass and Weight of Objects"
- "Worksheet: Measuring the Mass and Weight of Objects"
- "Handout: The Metric System"
- "Handout: Measuring the Volume of Liquids"
- "Worksheet: Manually Calculating Density"
- "Handout: Calculating Density"
- "Worksheet: Manually Calculating the Volume, Mass, and Density of Regularly Shaped Solid Objects"
- "Handout: Measuring and Calculating the Volume, Mass, and Density of Regularly Shaped Solid Objects"
- "Worksheet: Measuring and Calculating the Volume, Mass, and Density of Irregularly Shaped Solid Objects"

- “Handout: Measuring and Calculating the Volume, Mass, and Density of Irregularly Shaped Solid Objects”
- “Handout: Buoyancy”
- “Handout: Buoyancy Challenge”
- “Handout: Final Report”
- “Final Report Rubric”
- “Step Sheet: Creating a Data Table and Accompanying Charts in Excel”
- “Step Sheet: Creating a Formula in Excel”

Web Resources – Content:
A list of linked web resources related to the content of this lesson can be found on the Lesson Page.

Web Resources – Excel:
A list of linked web resources for Excel can be found on the Excel Resources page.

Assistive Technology:
Please refer to the Assistive Technology section for information on methods and devices to help ensure that all students have access to the curricula in the least restrictive environment.