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Buoyancy

Student Handout

In the following handout, students will be required to:

- Develop a method to uncover the hidden message, without lifting or opening the bottle
- Record observations and results
- Brainstorm the answers to the handout questions, and how the experiments relate to buoyancy

Provided in this document are sample answers (pages 2-5) and a blank handout (pages 6-9). The blank handout should be made available to each group prior to the activity.

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Buoyancy - Handout Answers

Student Handout - Answers

Buoyancy:

Here are some useful concepts:

- Buoyant force (F_b):
  - *The weight of the fluid (gas or liquid) displaced by a body submerged in the fluid, measured in newtons. It is expressed as an upward force.*
    *F_b = density of fluid * acceleration due to gravity * volume of displaced fluid*
- Weight (W):
  - *The measure of an object's heaviness. A downward force equivalent to force of gravity ($W = F_g = mg$) acting on an object.*
- Net force (F_{NET}):
  - *The sum of the forces acting on an object. For an object experiencing a buoyant force:*
    $F_{NET} = F_b$ (upwards) + F_g (downwards)

1) What is the difference between mass and weight?

Mass (m) is a measure of the amount of matter in an object. Weight is equivalent to the gravitational force acting on an object, and therefore depends on gravity ($W = F_g = mg$). Practically, weight tells us the heaviness of an object.

2) Why will the same object weigh less on the moon, for example, compared to on Earth? Does the object's mass change?

Weight changes depending upon the acceleration due to gravity ($W = mg$). This is the reason why the same object will have a different weight on Earth compared to on the moon, which has an acceleration due to gravity of only 1.6 m/s^2. Mass is independent of changes in gravity, thus an object's mass is the same anywhere in the universe.

3) Does the weight (heaviness) of an object change under the influence of a buoyant force?

In the absence of a buoyant force, the weight of an object is equal to the gravitational force ($W = mg$). If a buoyant force is introduced, it acts in opposition to the gravitational force, decreasing the "actual weight" (W) of the object ($W' = W - F_b$). The object actually gets lighter but mass is still conserved.

Buoyancy - Handout Answers

4) What is the difference between "actual weight" and "apparent weight"?

These definitions are used in Archimedes' principle. "Actual weight" is the weight of an object in the absence of a buoyant force (W = mg) and "apparent weight" is the reduced weight of an object which is under the influence of a buoyant force (W' = W – F_b). When a buoyant force is acting upon an object, the object will actually be less heavy.

5) What is the net force acting on an object which is a) rising, b) falling and c) statically floating (suspended)?

a) For an object which is rising, the buoyant force exceeds the gravitational force, and the net force is upwards, b) for a falling object, the gravitational force exceeds the buoyant force, and net force is downwards and c) for a statically floating object, the buoyant force is in equilibrium with the force of gravity, and the net force is zero.

6) What does a balance measure?

A balance measures the mass of an object. It does this indirectly by comparing the weight of the object (W = mg) to the weight of a reference object of known mass. If the measured mass is multiplied by the acceleration due to gravity, the gravitational force is obtained (F_g = w = mg). In the case where the object being weighed is also under the influence of a buoyant force, the balance reading no longer reflects the mass, but instead gives an "apparent mass" which is less than the true mass of the object. The difference in "apparent mass" and "actual mass" is equal to the mass of the fluid which is displaced. Recall that the F_b is equal the mass of displaced fluid multiplied by the acceleration due to gravity.

7) What are some practical applications of the buoyant force?

In hot air balloons, the balloons float because the buoyant force exceeds the gravitational force. Also, submarines use changes in buoyant force to either rise or sink. This is done by changing the density of the fluids contained in the submarine tanks.

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Buoyancy - Handout Answers

As you complete the three stations, fill in this handout with the information you have found.

Station I: Find the Hidden Message

Find the message without lifting the bottle. What is the message?

A, B, or C. Each letter corresponds to a different bucket in Station III (A - water, B - salt water and C - isopropanol).

How was the message discovered?

To discover the message, the bottle is squeezed. This action causes the test tube to sink, revealing the message.

Station II: Conservation of Mass

Record the balance readings before and after the white substance is added to the water in the bottle. To determine if a change in mass has occurred, subtract these values.

	Mass (g)	
BEFORE: Bottle + balloon + water + white substance	**115.87 (antacid)**	**114.62 (sugar)**
AFTER: Bottle + balloon + water + white substance	**1134 (antacid)**	**114.59 (sugar)**
Change in mass	**247 (antacid)**	**0 (sugar)**

If a change in mass has occurred, select a diet pop can to use in Station III, and vice versa.

Students who had antacid will observe a change in mass, which corresponds to the mass of displaced air. Students who had sugar will not observe a change in mass after the addition to water.

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Buoyancy - Handout Answers

Station 3: Pop Floats

Record your observations in this table.

Bucket label (determined in Station I)	**A (water), B (salt water), or C (isopropanol)**
Diet or regular pop (determined in Station II)	**Diet pop can, if a change in mass was observed in Station II** **Regular pop can, if no change in mass was observed in Station II**
Station III result	**Regular pop in bucket A - sinks** **Diet pop in bucket A -floats** **Regular pop in bucket B - suspended or floats** **Diet pop in bucket B- floats** **Regular pop in bucket C- sinks** **Diet pop in bucket C- sinks**

The results from Station III will differ depending upon the type of pop and the density of the fluid in the bucket. In general, when the density of the surrounding fluid is greater than the density of the pop, the can will float at the surface, and conversely, when the density of the pop exceeds the density of the surrounding fluid, the can will sink. The regular pop can will remain suspended, if the density of the salt water is equal to the density of the pop. See *Additional Information* for further explanation.

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7) What are some practical applications of the buoyant force?

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Station I: Find the Hidden Message

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How was the message discovered?

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	Mass (g)
BEFORE: Bottle + balloon + water + white substance	
AFTER: Bottle + balloon + water + white substance	
Change in mass	

If a change in mass has occurred, select a diet pop can to use in Station III, and vice versa.

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Station III: Pop Floats

Record your observations in this table.

Bucket label (Station I)	
Pop type (Station II)	
Station III result	