Simple observations of Archimedes's principle

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Anyone who has ever lifted a heavy submerged object out of water is familiar with *buoyancy*, the upward force that is exactly opposite to the direction of gravity's pull. It is a consequence of pressure increasing with fluid depth. The relationship between buoyancy and volume displaced is given by Archimedes' principle which states that "When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it."

Whether an object will sink or float in a liquid depends on how the buoyant force compares with the object's weight. This, in turn, depends on the object's density. Furthermore, an object feels lighter when held in water as compared to when it is held in air. This is because of the upward force of water. The difference of the object's weight in air with its weight in water actually gives us the buoyant force.

For this experiment all we need are three eggs, a bag of salt and three glasses or beakers. Firstly, fill all glasses with the same amount of water and add a decent amount of salt in two of the three glasses, keep stirring until the salt in each of them is completely dissolved. Let's see what happens when we put an egg in fresh water, another egg in salt water and the third egg in the second glass of seawater while we add some fresh water to it. Explain your observations qualitatively. Why does the egg in three different scenarios sink or float to different heights.

Figure 1: Three eggs are shown above. One egg is placed in fresh water, another is placed in saltwater and the last is placed in saltwater which is further diluted by addition of fresh water on top of it.

Now if we place the third beaker on a hot plate, and stir until no more salt dissolves, the egg will rise up. Explain, this observation and discuss with your lab instructors?

Q 1 An object floating in mercury has one-fourth of its volume submerged. If enough water is added to cover the object, what fraction of its volume will remain immersed in mercury? [**1**]

Now in order to quantitatively demonstrate Archimedes's principle, we will make use of a hollow plastic ball, a force sensor and two beakers of water. The hollow plastic ball by itself will float in water, however we can make it sink by filling it up with sand. Once the ball has been filled with sufficient sand, it will sink. The ball will then be inserted into a beaker filled with water, and the apparent weight of the ball will be measured using the provided force sensor, after which the ball will be taken out of water and its weight in air will be measured. While the weight of displaced water can be found by gently placing a plastic ball (attached to a thread) in the tilted beaker, causing it to pour out.

Figure 2: (a) The beaker filled with water has been tilted and is placed next to the empty beaker. (b) Placing an object in the tilted beaker displaces the water, causing it to pour out. This displaced water is being captured in the beaker next to it

Figure 3: The provided apparatus for verifying Archimedes's principle

Q 2 Using the setup as shown above, we would like you to investigate the following points.

1. Find the magnitude of buoyant force acting on sand filled ball.
2. Verify Archimedes' principle for the sand filled ball.
3. Find the density of sand filled ball using Archimedes' principle. Find the percent discrepancy between your measured and the density measured by some other techniques.

References

[1] David Halliday, Robert Resnick and Kenneth S. Krane, "*Physics*", John Wiley & Sons, Inc., pp. 383–390 (1992).

[2] Paul G. Hewitt, "*Conceptual Physics*", Inc., pp. 252–258 (2012).