Fun with Archimedes' principle

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Archimedes law stating that anybody completely or partially submerged in gasses as well as liquids (i.e. a fluid) rest is acted upon by an upward, or buoyant, force the magnitude of which is equal to the weight of the fluid displaced by the body. We are going to show few simply experiments demonstrating Archimedes' principle. Proposed experiments allow us to determine the density of examined liquid. Physics experiments can be done at home and involves very basic elements that anyone has access to, like water, plastic box, coins and balance. This complex concept is made more accessible to young explorers through the use of interesting demonstrations and experiments like the ones described below.

Experiments

1. Salt water eggs experiment

Using Archimedes' principal, children can determine if an object will sink or float in different density of water. Prepare a clear transparent beaker with warm water. Add an egg and it will sink (Fig. 1a). Add salt to the beaker and the egg begins to float (Fig. 2b). According to the Archimedes' principal: If an object weighs more than its own volume in fluid, it will sink. The mass per unit volume of water due to adding the salt was increased and was equal or more dense than egg and caused the egg float.

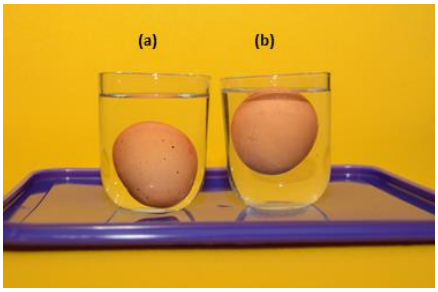

Fig. 1. (a) Egg into beaker of water without salt; (b) Egg into beaker of salt water

2. Density

An interesting experiment for the young explorers is to show how the weight changes result on the object flowing. Use two the same volume elements but with different mass. Lower exanimated objects into a beaker of water and observe the level of immersion of object with different mass (Fig. 2).

Fig. 2. The level of immersion of two object with different mass but with the same volume.

3. "Smuggling boat"

Using Archimedes' principal, children can determine if an object with different volume will sink or float in water. Prepare a main big transparent plastics box with water, stone and a smaller plastic box. Put the stone into a small plastic box and *put this in a box with water. I*t will sink (Fig. 3a). Now, do the same experiment, but this time fix a stone to the bottom of a small box **using a tape (Fig. 3b).** *In this case the boat floats. In the second case, the boat's density is less than the water's density causing the boat to float.*

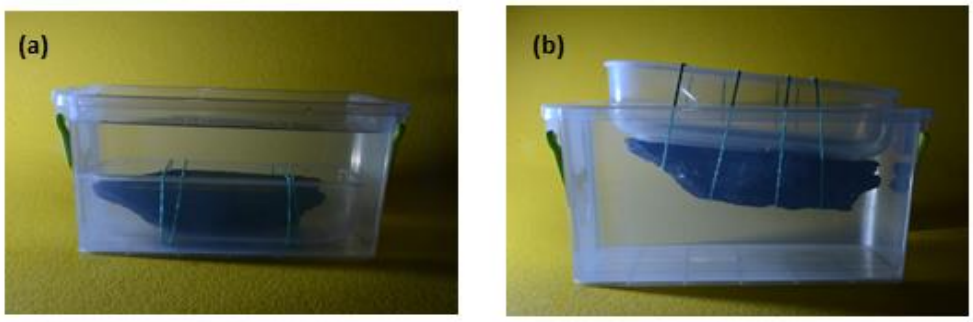

Fig. 3. A boat made of identical mass pieces. (a) Boat sink (b) Boat floats

4. Eureka! Eureka!

Determination of metal density by direct measurement of volume and mass.

The legend has it that the King Hieron II of Syracuse had summoned Archimedes and asked him to devise a way of finding out if the crown created for him by goldsmith was made from lump of gold. King Hieron suspected that the smith had stolen some of the gold, replacing it with cheaper silver.

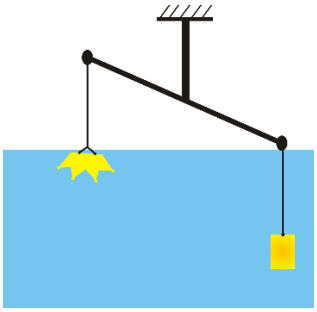

Fig. 4. Scheme of Archimedes experiment

As legend relates, the solution came to Archimedes as he bathed; he sat in the bath, noticed how the water level rose and this suddenly inspired him. To solved this problem Archimedes had prepared two equal mass crown one form block of gold and one from a block of silver. Then, Archimedes had immersed each in water, carefully measuring how much water was displaced (Fig. 4). After this experiment he had calculated that the crown was less dense than the gold but denser than the silver, indicating that the smith had cheated the King Hieron.

5. Determination of water density.

Archimedes principle says that when an object is immersed in a water the apparent loss of weight of an object is equal to the upthrust and this is also equal to the weight of the liquid displaced. The children can check this theory by the simply experiment. Prepare a main big transparent beaker with water, object (e.g. aluminum cylinder) with the density greater then examined liquid, the spring and pan balance, thread and a tape. Weigh the beaker with water using pan balance m_t (Fig. 5a). Estimate the volume of a cylindrical object V. Using the tape glue the thread to object. Lower exanimated object into a beaker of water that is not resting on a top pan balance and does not touch any of the beaker wall. Weigh the beaker with object inside m_p (Fig. 5b).

If you already know the volume of the object then you can simply measure the density of water (liquid) using following formula $\frac{m_c}{V} = \frac{m_p - m_t}{V} = \rho_{liquid}$ (where m_c –is the mass of the fluid displaced by the body)

Fig. 5. (a) Mass of the beaker of water; (b) Mass of the beaker of water with cylindrical object inside

Conclusion

The aim of this paper is to present the main physical problems in a very approachable and interesting way and using very basic elements. Presented experiments were realized during the Academy of Young Explorers to increase the attractiveness of STEM classes for all young people. We believe that access to high quality STEM learning gives the chance to become the innovators and researchers. Participation in Academy of Young Explorer would support development of experimental skills of the participants, which may be useful in their future carriers.

Literarture

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Photo by I. Hajdusianek