Experiment clarifies buoyancy

ARCHIMEDES' PRINCIPLE

Experiment clarifies buoyancy

Almost all basic physics textbooks cover Archimedes' principle (floating and sinking). However, many explanations are either incomplete or over complicated. This article presents a simple activity using Archimedes' principle that helps students to develop their scientific thinking and also to identify and correct their misconceptions. The exercise consists of linear and reverse processes.

Archimedes' principle states that a body immersed in a fluid is buoyed up by a force equal in magnitude to the weight of the displaced fluid. Therefore the upthrust depends on two variables ($\vec{F} = \rho_{liquid} V_{immerse} \vec{g}$): the density of the liquid and the immersed volume of the body.

A fresh tangerine, a piece of aluminium foil or plastic clingfilm, modelling clay and a cup of water are sufficient to teach Archimedes' principle. Citrus fruit have special structures including that, because of the density of their peel, they float when they have the peel intact and sink when they are peeled.

First, the students discussed whether they thought that the tangerine would float or sink in a cup of water. They then designed an experiment to show how the tangerine would sink and finally they considered how to refloat the sunken tangerine. During each process a similar procedure was followed: students were given a short description of the problem, then they were asked to formulate a hypothesis, to design an experiment or to make an observation, and finally to interpret their results.

During the activity the following misconceptions

by the students were noted:

- that the lifting force of the fluid depends on the amount of liquid;
- that the lifting force depends not only on the density of the liquid but also on the density of the immersed body;
- that some materials float and some sink.

The tangerine was floating in a cup of water. If the first misconception was correct then changing the amount of water should make the tangerine sink. However, it remained buoyant even though nearly half of the water was poured away. Students corrected their misconception by testing it.

For the second and third misconceptions, a piece of aluminium foil was floated on the water. It was then folded several times (with no trapped air bubbles) and it sank in the water. This proved that the density of the immersed body did not affect its buoyancy. However, the students observed that changing the shape of an object alters the surface area that comes into contact with the water, and that this is what determines its buoyancy.

The same experiment was carried out using a piece of modelling clay. It floated when moulded into a flat and wide shape, and it sank when moulded into a sphere—the same piece of clay floated or sank according to its shape. The students concluded that any material can be floated or submerged in suitable conditions and that the fluid lifting force depends on the density of the liquid and the immersed volume of the body.

Conclusion

During the linear process, students observed tangerines floating when unpeeled and sinking when peeled. They could have concluded that immersion depends on the body's volume and mass because the tangerine peel's mass and volume could not be discounted. However, during the reverse process, they observed that an unpeeled tangerine would still float when wrapped with aluminium foil or plastic clingfilm. The mass of foil or clingfilm was insufficient to make it sink and the volume of the tangerine was hardly changed.

These experiments proved that Archimedes' principle depends on only the volume, not on the mass. During the linear process, teachers recognized students' misconceptions but could not specify what they were. During the reverse process they identified and corrected them by designing additional activities. This activity showed that the reverse processes enabled learners to overcome their misconceptions and reinforce their understanding. The feedback from the students confirmed that they found the activity both interesting and stimulating.

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