“HANDS ON” EXPERIMENTS IN DEVELOPING CONCEPTS OF ARCHIMEDES’ LAW

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ABSTRACT

Inquiry learning supports going beyond data and information accumulation and moving toward the generation of useful and applicable knowledge. Inquiry in education should be about students greater understanding of the world in which they live, learn, communicate, and work. In inquiry-based learning “Hands on” experiments are of great help. In order to understand better concepts of Archimedes’ law besides theoretical explanation, questions and examples, the implementation of simple experiments (“Hands on”) into the educational process is helpful. Suggestion for formation and development of the concepts of Archimedes’ law in the teaching process is given in this work.

Keyword: “Hands on” experiments, buoyancy, Archimedes’ law, floating, sinking, hovering

Introduction

The accelerated process of accumulating scientific knowledge in the last decades of the previous century, accompanied by the technical-technological development, has left unconcerned a large portion of human population. This has greatly been reflected on the interest of school-goers in acquiring knowledge from fundamental disciplines. The extraordinary discoveries that have been made in physics as fundamental disciplines have apparently produced an opposite effect. Instead of an enhanced interest in studying them, the learners often feel certain reluctance and distrust in their own capacity for understanding and solving the given tasks. Modern education should represent a unified teaching-learning process, which includes both the teacher and learner as active participants in accomplishing the preset goals. Most of the teachers ask if there is a “best” known way to teach. The most effective teaching method depends on the specific goals of the course and the needs of the students. New standards based approaches to instruction present challenges to both teachers and students. For teachers using instructional methods based on recitation and direct instruction, inquiry teaching challenges them to develop new content knowledge, pedagogical techniques, approaches to assessment, and classroom management [1, 2]. Inquiry learning requires students to increase in science content understanding, construct usable knowledge by linking new and old ideas, relate new science content to their lives in and outside of school, and self-regulate across the weeks that an inquiry project might unfold. For inquiry learning it is necessary an implementation of simple experiments (“Hands on”) into the educational process [3]. “Hands on” experiments can be performed by pupils having a small written laboratory guide. The pedagogical value of the experiment is supported by the low cost of the experimental setup and by the simplicity of the procedures involved. These experiments get
pupils interested. Also they make pupils active during teaching process and that fact reflects in better understanding of natural phenomena and physics.

Archimedes' principle
Buoyancy is an upward acting force exerted by a fluid that opposes an object's weight. This is the force that enables some objects to float. This can occur only in a reference frame which either has a gravitational field or is accelerating due to a force other than gravity defining a “downward” direction (that is, a non-inertial reference frame) [4].

Archimedes' principle is named after Archimedes of Syracuse, who first discovered this law. He determined that: Any object, wholly or partially immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object (Figure 1).

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\vec{F}_p = -\rho \vec{V} \vec{g}
\]

Figure 1. Archimedes' law

Formation and development of the concepts of Archimedes' law

In the teaching process in elementary education we can form and develop concepts of Archimedes' law by application of problem questions and simple experiments.

Structure of knowledge in the chosen area consists of the following concepts:
- buoyancy,
- Archimedes' law,
- floating,
- sinking,
- hovering

It is known that inquiry is not only done in laboratory or group work – it can also be done in lectures that provoke students to think and question. In this theme question for students can be: How helium balloons work? You can hold its string and it will ride along above you. If you let go of the string, it will fly away until you can't see it anymore. Why?

Will the body immersed in water float, sink or hover depends on intensity of gravity and buoyant force that act on it. When intensity of gravity is greater than intensity of buoyant force
body will sink. When the intensity of gravity is less than buoyant force the body will go upward until it floats partially immersed in water. When both forces are the same intensity the body is hovering.

Helium is lighter than air so the gravity is less than buoyant force acting on it and it flies.

**Experiments**

1. *Does lemon float or sink?*

   This experiment is very simple and can be used with children from the youngest age to demonstrate sinking and floating and explain role of density in Archimedes’ principle.

   **Aim:** density, buoyancy, Archimedes' law, floating, sinking

   **Materials:** lemon, glass, water

   **Experiment:** Put a lemon in a glass of water. Will it sink?

   Now pill a lemon and put it again to see if it will sink now (Figure 3).

   **Explanation:** Lemon rind is thick and porous and contains little air pockets. Density of whole (unpeeled) lemon is less than density of water so it will float. Density of peeled lemon is greater than density of water so it will sink.

2. *Why we can't measure air weight with balance*

   This experiment is valuable for elementary school because children will learn that air have weight although we can’t measure it with balance.

   **Aim:** weight, buoyancy, Archimedes' law

   **Materials:** ruler, paperclips, 2 balloons, 4 marbles, rubber bends, transparent jar, water

   **Experiment:** With paperclips and ruler make a balance. In both balloons put 2 marbles and fill them with different amount of water so there is no air in them. Fill the jar with water. Put balloons in balance in water (Figure 4, left) and than pull the ruler with balloons out of water to see what will happen (Figure 4, right).

   **Explanation:** This demonstration can be done to illustrate why we can’t measure air weight with balance. Balloons immersed in water are in balance when they are equally distant from the center of ruler. Buoyant force that acts on balloon immersed in water (which we can determine by using Archimedes’ principle) is equal to gravitational force that acts on water in it, so the net force is zero and because of that both balloons have the same weight while immersed in water. That is approximately the weight of marbles. In air there is obvious difference in weights of two balloons. We can conclude that water does not weigh in water. The same is with air – air does not weigh in air [5].

Figure 3. Does lemon float or sink?

Figure 4. Why we can’t measure air weight with balance
3. Fun Cartesian diver

This is an excellent experiment for kids. They will learn about buoyancy and gravity while they are playing with toy that they have made themselves.

**Aim:** density, weight, buoyancy, Archimedes' law

**Materials:** plastic bottle with cap, test tube, paperclips, plasticine, 3 plastic rings, water

**Experiment:** Plastic rings make more massive with paperclips so they will sink. On a test tube with plasticine attach hook made from paperclips. Test tube should gain mass so it will float completely submerged in water when put upside down. Fill the bottle with water, place plastic rings and test tube (turned upside down) and close it hard. Try to hook the rings from the bottom (Figure 5). To lower the diver, the player squeezes the bottle which makes the diver move downwards. The player then tries to manoeuvre the hook to grab as many of the loops as possible [6].

**Explanation:** There is just enough air in the diver to make it positively buoyant so the diver floats at the water's surface. As a result of Pascal's law, when the pressure is increased by squeezing the bottle, the pressure on the water increases the pressure on the air bubble in the diver. The air compresses and reduces volume, permitting more water to enter the diver. The diver now displaces a lesser weight of water and gravitational force is now greater than buoyant force that acts on it (it becomes negatively buoyant) and because of that it sinks. When the pressure on the bottle is released, the air expands again, increasing the weight of water displaced and the diver again becomes positively buoyant and floats. If the weight of displaced water exactly matches the weight of the diver, it will neither rise, nor sink, but hover in the middle of the bottle.

We can also give an explanation which is convenient for developing of concept of density. The diver originally floats because it is less dense than water. When the bottle is squeezed which causes the increase of water level in the diver, its density increases and when it is denser than water it sinks to the bottom of the bottle.

After this experiment we can ask students can they explain how swim bladder works.

Most fish have swim bladders as their important adaptation to the life in the water (Figure 6). A swim bladder is an air sac that allows a fish to change depth by using the same principle as explained on example of Cartesian diver. The transfer of gases between the swim bladder and the blood causes the swim bladder to inflate and deflate. As the swim bladder fills with gases the fish rises in the water and when the swim bladder deflates the fish sinks. Fish that live without a swim bladder like shark will sink if it stops swimming.

**Conclusion**

Problem questions and simple experiments are of great help in teaching process. The application of some simple experiments was demonstrated in the realization of the Archimedes' law, floating, sinking, and hovering. The selected simple experiments can be conducted with students from the youngest age. The procedures for preparation and the conduction of experiments are given, as well as the explanations. Explanations and comments should be adjusted to students' age. Some of them can be simplified and presented only on the phenomenological level, but...
always keeping in mind the danger of doing it half-way with the young children, so that the first memory of a physical phenomenon shouldn't be the wrong one.

Figure 6. Workshop for children (held in American Corner in Novi Sad)

References


