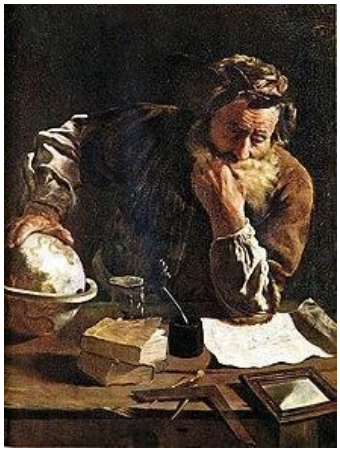
Archimedes' Principle

Respective blueprint	Archimedes' Screw
Description	Learning the properties of the buoyant force and Archimedes' Principle.
Learning Objectives	For students to become familiar with the: • Force of Buoyancy • Archimedes' Principle
Related curricular subject(s)	Science - Physics
Prerequisites / preparatory actions for teachers	Teachers should make sure that pupils are familiar with the concepts of volume, density and force (Newton's second law) before continuing with the pedagogical sequence.
Prerequisites / preparatory actions for students	Students should know: • The difference between mass and weight • The concept of volume and what is a force (Newton's second law). • Formula for the volume of a sphere: $V = \frac{4}{3}\pi r^3$

	• Formula for density ($\rho = m/V$) • Units of measurements (kg, m/dm/cm, m^3)
Age of students	14 – 16 years old (depending on local curricular)
Duration	1 - 2 hours
Level of difficulty	Difficult

Step by step description of the tasks

Step 1: Who was Archimedes?



Source: wikipedia.org

- What accomplishments was Archimedes known for?

In the 3rd century B.C., Archimedes discovered a law of buoyancy, Archimedes' principle: Archimedes' principle states that a body totally or partially immersed in a fluid is subject to an upward force (buoyant force) that is equal in magnitude to the weight of fluid it displaces. Thus, the net upward force on the object is the

difference between the buoyant force and its weight. If this net force is positive, the object rises; if negative, the object sinks; and if zero, the object remains in place without either rising or sinking.

- What led to Archimedes' discovering his principle?

Legend says that Archimedes discovered the principle of displacement while stepping into a full bath. He realised that the water that ran over equalled in volume the submerged part of his body. Through further experiments, he deduced the above-mentioned Archimedes' principle. The legend goes further and tells that Archimedes was so excited with his discovery that he hopped out of the bath, and rushed naked into the street yelling triumphantly, "Eureka!" "Eureka!" (the Greek word for 'I have found it!).

Step 2: Weight and Buoyant Force

Weight is a measure of the force of gravity pulling down on an object, whereas buoyant force pushes up on an object. The force that is greater determines whether an object sinks or floats. Look at Figure 2. On the left, the object's weight is the same as the buoyant force acting on it, so the object floats. On the right, the object's weight is greater than the buoyant force acting on it, so the object sinks.

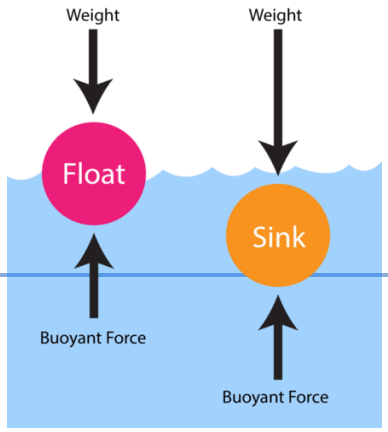


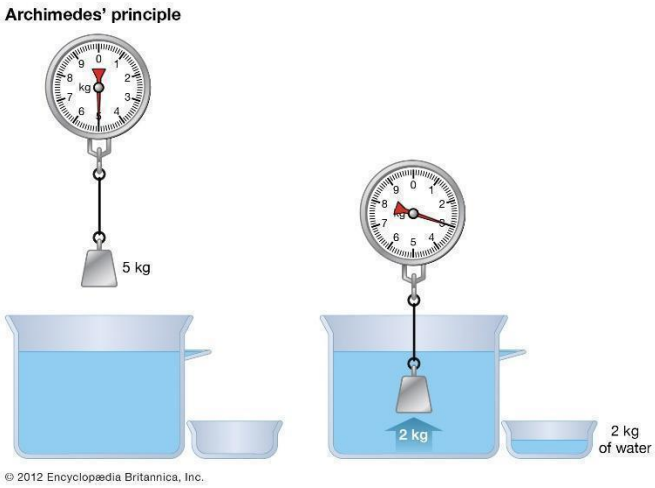
Figure 2 / Weight and Buoyant Force

source: flexbooks.ck12.org

Step 3: Archimedes' Principle

Teachers guide students to learn that putting an object into the water moves a volume of water.

- Principle: A body at rest in a fluid is acted upon by a force pushing upward called the buoyant force, which is equal to the weight of the fluid that the body displaces. If the body is completely submerged, the volume of fluid displaced is equal to the volume of the body. If the body is only partially submerged, the volume of the fluid displaced is equal to the volume of the part of the body that is submerged.



Archimedes' principle of buoyancy. Here, a 5kg object immersed in water is shown being acted upon by a buoyant (upward) force of 2kg, which is equal to the weight of the water displaced by the immersed object. The buoyant force reduces the object's apparent weight by 2kg—that is, from 5kg to 3kg.

- Formula of Archimedes principle

Just as stated earlier, Archimedes law states that the buoyant force on an object is equal to the weight of the fluid displaced by the object. It is written mathematically as:

$$Fb = \rho * g * V$$

where:

- Fb is the buoyant force
- ρ is the density of a fluid
- V is the submerged volume
- g is the acceleration due to gravity.

So, the denser the fluid is, the greater the buoyancy and the buoyant force.

Assessment activities	The following questions could be made by the teacher to evaluate the activity or to be given as homework: **Possible Question 1:** • Which of the following is a statement of Archimedes' principle? Possible Answers:

	i. Buoyant force is the weight of the mass of water displaced by an immersed object **ii.** Buoyant force is the weight of the volume of water displaced by an immersed object iii. Buoyant force is the weight of the mass of an immersed object. **Possible Question 2:** Determine the resultant force using the Archimedes' Principle Formula, if a steel ball of radius 6cm is immersed in water. Assume the density of lead as 7900 $\frac{kg}{m^3}$ Solution: Radius of the steel ball, r = 6cm = 0.06m Thus, volume of the steel ball will be, $$V = \frac{4}{3}\pi r^3$$ i.e. $$V = \frac{4}{3}\pi(0.06)^3$$ thus,

	$V = 9.05 * 10^{-4}\ m^3$ density of water, $\rho = 1000\,\frac{kg}{m^3}$ $g = 9.8\ m/s^2$ Now, the formula for Archimedes' principle is: Fb = ρ*g*V = 1000*9.8*(9.05*10^{-4}) = 8.87 N Thus, the resulting force will be 8.87 N.

References:

1. Britannica, Archimedes' Principle, Available Online: https://www.britannica.com/science/Archimedes-principle
2. Ernest Z., 2014, How do density and buoyancy relate?, Socratic Q&A Chemistry, Available Online: https://socratic.org/questions/how-do-density-and-buoyancy-relate