Gravitation - Lesson 20
Archimedes' Principle

The only parameter to consider for buoyancy is the weight of the water/liquid displaced by the fluid. If the weight of the fluid displaced by the object is equal to the weight of the object, then the object will remain afloat. **Therefore, the force experienced by an object when immersed in a liquid is equal to the weight of the fluid displaced.** This was the principle stated by Archimedes, often known as the *EUREKA* moment.

He came across this principle while pondering about a problem given by the king of his state, Syracuse. The problem was to make sure that his crown was made from pure gold. During his extensive mental exercise of finding the solution, he thought the water displaced or the change in the level of water by the gold crowns would be equal to the volume of the crowns. If volume is known, one can weigh the crowns and deterine its density. He knew that the density of pure and impure crown will be different as adding impurity will changes the density. This happened when he was bathing and lying down in his bathtub, which made the water spill out of the bathtub and made him think along the above lines. Legend has it that at this moment, Archimedes ran through the streets of Syracuse, naked, shouting *EUREKA (I've got it)!*

This is also why we feel lighter when inside a swimming pool. We displace some volume of water, and its corresponding weight is the opposing force experienced by us, which is always

acting opposite to gravity and hence, we feel lighter. The spoon sinks because it cannot displace enough water to be afloat. This is the reason why ships have a humungous bottom surface area. The same fact is valid for a hot air balloon. A hot air balloon essentially works because it has a huge volume of air which is hot and hence, lighter. So the same volume of hot air weighs less than the cold, surrounding air. And thus, the buoyant force experienced by the hot air balloon is more than its weight, and so it rises and rises until the forces cancel each other or the hot air inside the balloon becomes cold.

This principle is used in various ways. It is used to design hot air balloons, submarines, and ships of all sizes. It is also used to detect the impurity of milk by lactometers. The same principle is used by hydrometers to determine the density of a fluid.

You should, now, be able to answer the following questions:

1. State Archimedis' princple?
2. How can you measure the exact volume of an irregularly shaped object?
3. Explain the conditions under which an object remains afloat on a fluid?

Conclusion

An object when immersed in a fluid displaces the fluid according to its volume and the weight of this displaced fluid is the upward buoyant force experienced by the object.

Note to Teacher

The text introduces Archimedes' principle by delving into the history and stating the chain of events that might have led Archimedes to the concept of buoyancy. The text describes the parameter considered to calculate buoyant force. The goal here is to understand why an object floats ot sinks, which will ultimately lead to density.

Student Worksheet

1. How does a ship float on water even though the ship is so heavy?
2. Why you have to beat your hands and legs in water to swim?
3. When measuring our weight on a weighing scale, are we really measuring our complete weight? If no, explain why?
4. What are lactometers used for?
5. What are hydrometers used for?

Answers

1. 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.
2. By completely immersing the object in a fluid and measuring the change in the level of fluid.
3. When an object is immersed fully or partially in a fluid, if the weight of the fluid displaced is more than the weight of the object, the object will remain afloat.

Student Worksheet Answers

1. The weight of water displaced by the ship is greater than the weight of the ship.
2. Our body's volume is not enough to displace enough amount of water. Beating hands and legs displaces extra water in order for us to remain afloat.
3. No. In reality, we displace certain volume of air which exerts a force equal to the weight of the air displaced. This decrases the reading on the weighing machine. Hence, our weight is slight greater than it is shown in the weighing scale.
4. to determine the purity of a sample of milk.
5. for determining density of fluids.