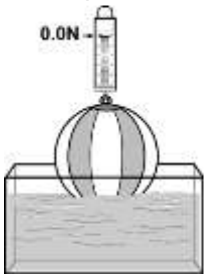
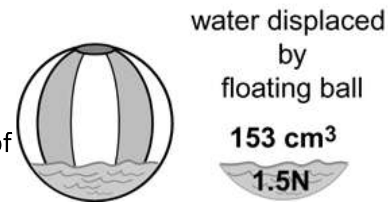
Chapter 16: **Archimedes Principle** Name:__________________________ Period:___

Have you ever tried to hold a beach ball underwater? It takes a lot of effort! That's because the buoyant force is much larger than the gravitational force acting on the beach ball.



Archimedes principle can be used to calculate the buoyant force acting on the beach ball. Archimedes principle states: The buoyant force acting on an object in a fluid is equal to the weight of the fluid displaced by the object.



In air, a beach ball weighs 1.5 newtons. However, if you measure the weight of a floating beach ball in water, a spring scale reads 0.0 newtons. The apparent weight of the ball is 0.0 newtons.

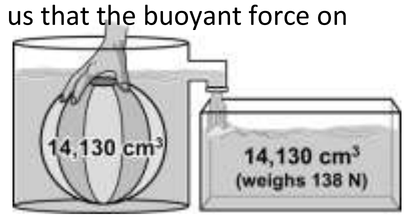
If you put the beach ball into the water and don't push down on it, you'll see that the beach ball floats on top of the water by itself. Only a small part of the beach ball is underwater. Measuring the volume of the beach ball that is under water, we find it is 153 cm^3. Knowing that 1 cm^3 of water has a mass of 1 g, you can calculate the weight of the water displaced by the beach ball.

153 cm^3 of water = 153 grams = 0.153 kg
weight = mass × force of gravity per kg = (0.153 kg) × 9.8 N/kg = 1.5 N

According to Archimedes principle, the buoyant force acting on the beach ball equals the weight of the water displaced by the beach ball. Since the beach ball is floating in equilibrium, the weight of the ball pushing down must equal the buoyant force pushing up on the ball. We just showed this to be true for our beach ball.

Now let's calculate the buoyant force on our beach ball if we push it all the way under the water. Completely submerged, the beach ball displaces 14,130$cm^3$of water. Archimedes principle tells us that the buoyant force on the ball is equal to the weight of that water:

14,130 cm3 of water = 14,130 grams = 14.13 kg
weight = mass × force of gravity per kg = (14.13 kg) × 9.8 N/kg = 138 N



If the buoyant force is pushing up with 138 N, and the weight of the ball is only 1.5 N, your hand pushing down on the ball supplies the rest of the force, 136.5 N.

Example:

A 5-cm^3 block of lead weighs 0.55 N. The lead is carefully submerged in a tank of mercury. One cm^3 of mercury weighs 0.13 N. What is the weight of the mercury displaced by the block of lead? Will the block of lead sink or float in the mercury?

Given	Solution
Volume of block = 5 cm^3 Weight of lead block = 0.55 N Looking for Weight of mercury displaced Will the lead sink or float? Relationships 1 cm^3 mercury weighs 0.13 N	The lead will displace 5 cm^3 of mercury. 5 cm^3 mercury X 0.13 N/1 cm^3 mercury = 0.65 N The buoyant force of mercury, 0.65 N, is greater than the weight of the lead, 0.55 N. Therefore, the block of lead will float.

Practice:

1. A 10 cm^3 block of paraffin (a type of wax) weighs 0.085 N. It is carefully submerged in a container of gasoline. One cm^3 of gasoline weighs 0.0069 N.
    a. What is the weight of the gasoline displaced by the paraffin?
    b. Will the block of paraffin sink or float in the gasoline?

2. A 30 cm^3 chunk of platinum weighs 6.3 N. It is carefully submerged in a tub of molasses. One cm^3 of molasses weighs 0.013 N.
    a. What is the weight of the molasses displaced by the platinum?
    b. Will the platinum sink or float in the molasses?

3. A 15 cm^3 block of gold weighs 2.8 N. It is carefully submerged in a tank of mercury. One $cm^3$of mercury weighs 0.13 N.
    a. Will the mercury be displaced by the gold?
    b. Will the gold sink or float in the mercury?

4. Compare the densities of each pair of materials in questions 1-3 above.
    a. paraffin versus gasoline
    b. platinum versus molasses
    c. gold versus mercury

5. A 10 cm^3 block of lead weights 1.1 N. The lead is placed in a tank of water. One cm3 of water weighs 0.0098 N. What is the buoyant force on the black of lead?

6. A 100 cm^3 block of lead that weighs 11 N is carefully submerged in water. One cm3 of water weighs 0.0098 N.
    a. What is the buoyant force on the lead?
    b. Will the lead sink or float?

7. The same 100 cm^3 lead block is now carefully submerged in a container of mercury. One cm3 of mercury weighs 0.13 N.
    a. What is the buoyant force on the lead?
    b. Will the lead block sink or float in the mercury?

6. Based on density, explain whether the object would float or sink in the following situations:
    a. A block of solid paraffin (wax) in molasses.
    b. A gold ring in molten platinum.
    c. A piece of platinum in molten gold.
    d. A drop of gasoline in mercury.
    e. A drop of mercury in gasoline.

Material	Density (g/ cm3)
gasoline	0.7
gold	19.3
lead	11.3
mercury	13.6
molasses	1.37
paraffin	0.87
platinum	21.4