Archimedes’ Principle and Density

Introduction
The purpose of this experiment is to investigate Archimedes' principle for an object that is more dense than water and an object that is less dense than water.

Equipment

Triple Beam Balance + Thread	Large Glass Beaker	Styrofoam Cup
Lab Jack	Overflow Can	Digital Lab Scale
Three Objects: Sinkers (2); Wood or Cork (1)		

Theory
Archimedes' principle states that an object floating or fully immersed in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the object.

The buoyant force on an object immersed in a liquid can also be determined by weighting an object in air and then in water. The apparent loss of weight of the object is equal to the buoyant force of the water.

To summarize:

Buoyant force on the object = apparent loss of weight of the object = Weight of object in air –“Weight” of object in fluid

Buoyant force on the object = weight of displaced liquid

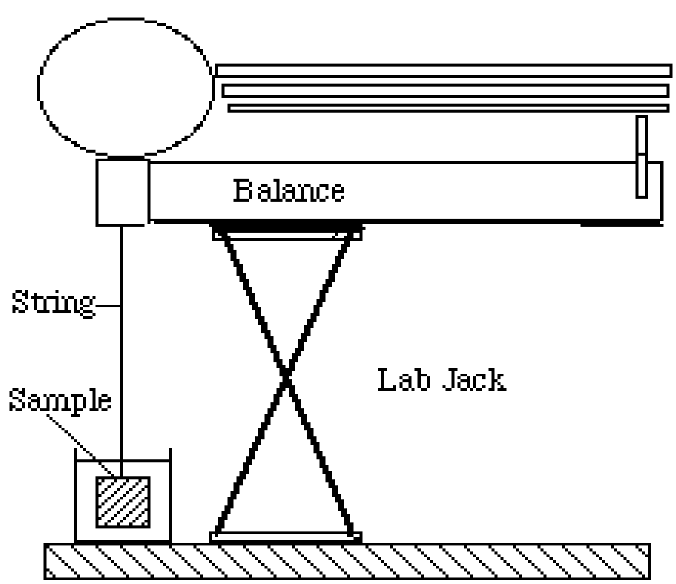

Figure 1.

<u>Procedure:</u>

Note: We will use grams as "force" units.

<u>Part 1 - Determine the buoyant force on samples *more* dense than water</u>.

Measuring the Apparent Mass

1. Attach the block to the bottom of the triple beam balance with the light thread as shown in Figure 1.

2. Measure the mass of the block and record in Data Table 1A.

3. Lower the block into the beaker of water so that it is completely below the surface without touching the sides or bottom of the beaker.

4. Measure the apparent mass of the block while it is submerged. This is the apparent mass of the block. Record this value in the Data Table 1A

5. Calculate the upward buoyant "force" exerted on the object by subtracting its mass in water (apparent mass) from its mass in air.

6. In the last column calculate the density of the block using the formula at the top of the table.

Measuring the Mass of Displaced Water

7. To find the mass of the water displaced by the block, fill the overflow can to the spout. Set the empty Styrofoam cup below the spout. Holding the thread, slowly lower the block into the overflow can until it is completely submerged. The displaced water will flow from the can into the cup.

8. Measure and record the mass of the displaced water in the Styrofoam cup.

Second Denser than Water Sample

Repeat the above steps for a second object made of a different material

DATA TABLE 1A

Trial	Mass of Block in Air (g) = M_{air}	Apparent Mass of Block in Water (g)	Apparent Loss in Mass (g) (BF = Buoyant Force)	Mass of Displaced Water (g)	Block Density = $M_{air}\rho_w/BF$	% Diff (Compare with values below)
Object 1			E_1 =	E_2 =		
Object 2			E_1 =	E_2 =		

Densities (g/cm^3)

Fe	Cu	Sn (Tin)	Al	Zn	Pb	Brass	Water
7.86	8.96	7.31	2.70	7.13	11.4	8.55	1.00

Questions:

1. Is the buoyant force equal to the weight of the displaced water? Calculate a percent difference for each trial.

$$\%\ difference = \frac{|E_1 - E_2|}{\frac{E_1 + E_2}{2}} \times 100$$

Trial 1 ____________________%

Trial 2 ____________________%

1. Why does the block *appear* to weigh less when immersed in water?

2. Based on the density values in the Table of Densities above, what was the identity of the samples that you used?

Object 1 ________________ Object 2 __________________

<u>Part 2 - Determine buoyant force on sample *less* dense than water</u>.

Measuring the Apparent Mass

1. Arrange a sinker and a wooden block so that the sinker is completely below the surface of water while the paraffin remains in the air. See Figure 2. The objects should be set up so that when the wooden object is lowered beneath the surface of the water the sinker does not contact the sides or bottom of the can

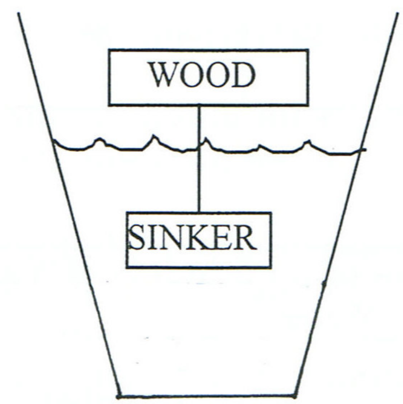

Figure 2. In air measurement

2. Carefully find the mass for this setup by reading the scale and record the value in Table 2A as M_1.

3. <u>Fill the beaker with more water</u> so that both sinker the wooden block are submerged.

4. Record the scale reading (the apparent mass) of the submerged wooden block and sinker as M_2 in Table 2A.

5. Find the upward "force" (buoyant force) exerted on the wooden block by subtracting M_2 from M_1.

Measuring the Mass of Displaced Water

6. To find the mass of the water displaced by the wooden block, fill the overflow can to the spout <u>with the sinker submerged</u>. Set the Styrofoam cup below the spout. With the sinker still submerged, slowly lower the paraffin (wooden) block into the overflow can until it is completely under water.

7. Measure and record the mass of the water in the Styrofoam cup in Table 2A.

DATA TABLE 2A

Mass of Block in Air and Sinker in Water M_1 (g)	Apparent Mass of Sinker and Block in Water M_2 (g)	Apparent Loss in Mass (Buoyant "Force") M_1 - M_2 (g)	Mass of Displaced Water (g)
		E_1 =	E_2 =

Questions:

1. Is the buoyant force equal to the weight of the displaced water? Calculate a percent difference for the trial.

$$\%\ \textit{difference} = \frac{|E_1 - E_2|}{\frac{E_1 + E_2}{2}} \times 100 = \underline{\hspace{4cm}}\ \%$$

2. Explain why a ball of clay sinks, but when shaped into a boat it floats.