Density and Archimedes' Principle

Purpose: To determine the density of several solids and a liquid by using Archimedes' principle

Equipment: Balance, string, samples of unknown density, vernier calipers, small beaker, water, table rod clamp, two short rods, right angle clamp, small block of wood, hook collar support clamp.

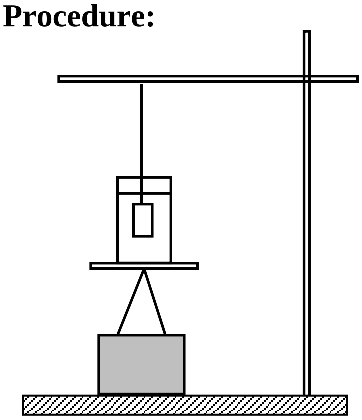
Introduction:

Archimedes' principle states that when a body is immersed in a fluid there is a buoyant force acting upward on the body equal to the weight of the displaced fluid. In equation form, the buoyant force, F_B, can be written as

$$F_B = m_L g$$

Where m_L is the mass of the liquid displaced. We can measure the buoyant force that is exerted on a solid placed in water (or any fluid of known density) by weighing a beaker of water and then weighing the beaker again after the mass has been completely submerged. (Hang the mass by a thread so that the mass is completely submerged but not resting on the bottom of the beaker.) Since the water exerts a buoyant force upward on the submerged solid, the solid also exerts a downward force on the water, which is shown by an increased reading on the scale. The mass of the liquid displaced is equal to the difference in the two readings (before and after the solid is submerged). The buoyant force can then be found from the above equation.

Procedure:



1. Measure the dimensions of one of the metal cylinders provided and calculate its volume. Measure its mass on the balance and then find the density by direct calculation ($\rho = m/V$). Repeat for two other solids. Place all data in a neat table.

2. Fill a small beaker with enough water to cover completely the solid cylinders used in part 1. Weigh the beaker and water combination on the scale. Now hang the cylinder by a thread and submerge it in the water, without touching the bottom of the beaker. Record the increased reading on the scale, Δm. The mass of the liquid displaced by the cylinder, m_L, is equal to Δm ($m_L = \Delta m$). From this mass calculate the volume of water displaced ($V = \Delta m/\rho$). This is, of course, also the volume of the submerged solid. Knowing the mass (from part 1) and now the volume, calculate the density of the solid by this independent method. Repeat for the other two solids and record all data in a neat table. Also record the accepted values for the density of the solids and compare with your two experimental values by finding the percent difference.

3. Measure the mass and dimensions of a small block of wood so that you can determine its density as in part 1.

4. Attach one of the metal cylinders to the block of wood with thread so that you can completely submerge the wood under water as before. Obtain readings on the balance before and after submersion and thus

determine the mass of the water displaced by both objects together. Subtract off the mass of water displaced by the cylinder (part 2) to obtain the mass of the water displaced by the wood only. (Work quickly since the wood will begin absorbing water and soon give an inappropriate reading on the scale.) From this mass calculate the volume of water displaced by the wood. Since this is also the volume of the wood, find the density of the wood using the mass obtained in part 3. Record all data in a table and compare the densities for the wood obtained in parts 3 and 4.

5. Determine the density of another liquid by repeating the procedure in part 2 using one of the solids whose density you have previously determined. Carefully explain you calculations. Repeat for the other two solids. Average you results and compare with the accepted value of the density for this liquid.