Physics 207 - Lab 7 - Buoyancy

Introduction

The hydrostatic pressure P at a distance h below the surface of a fluid is given by

$$P = P_0 + \rho g h$$

where P_0 is the pressure at the surface of the fluid and ρ is the density of the fluid.

The hydrostatic pressure exerts a normal force on all surfaces in contact with the fluid. As a result there is a net upward force, called the Buoyant Force, F_B, whose magnitude is equal to the weight of the fluid displaced, a relationship known as Archimedes' Principle:

$$F_B = \rho g V$$

where V is the volume of the object below the surface of the fluid. In this experiment, you will weigh objects in air and then measure the effect of submerging them in a fluid. A clearly labeled Free Body Diagram should be used to determine the forces on the submerged objects in order to relate your measurements to the density of the objects. If the fluid is water, assume the standard value for ρ of 1000 kg/m^3.

The electronic balance is turned on by pressing the button at the right. Pressing the button on the left quickly will change the units displayed. We will work with the gram scale. Note that this is the mass-equivalent of the force being measured, you do not have to actually multiply by the numerical value of g, leave it as a symbol and it will eventually cancel out.

Experiment 1

Determine the density of a solid more dense than water.

Method 1:

Weigh the metal object and then suspend it from the hook on the underside of the balance so that it is submerged in the beaker of water. This second weight, called the ”apparent weight” differs from the first due to the buoyant force. Draw the corresponding Free Body Diagram and use it to determine the forces involved, and to solve for the density of the submerged object. Calculate the buoyant force and the density from your measurements. Use the table of densities below to estimate the composition of the metal. Does it appear reasonable from the appearance of the material? Explain.

Method 2:

An alternate procedure is to place the beaker on top of the scale and measure the change when the object is just submerged while being supported by the thread. Dry the metal object and weigh the beaker before (W_0) and after (W_1) the object is submerged. Do not let the submerged object touch the bottom of the beaker.

Report Questions

1. Compare the results of these two methods in in your report.

Experiment 2

Determine the density of an object less dense than water.

Weigh the wood block in air (this is the small wood piece with the groove in it, not the large wood platform). Attach the metal object to it so as to act as a ”sinker”. Use either method to determine the density of the wood block. Explain the procedure that you chose, including appropriate Free Body Diagrams.

Use the table of densities below to make a guess as to the type of wood provided.

Experiment 3

Determine the density of a liquid other than water.

You now have objects whose densities are known. One of them can be used as a test object to determine the density of the unknown liquid. Be sure that the object you use is as dry as possible. Use one of the earlier procedures to determine the buoyant force on the object, and calculate the density of the liquid.

Report Questions

2. How large a mass would have to be placed on top of the wooden block when floating in the water so that the block would be completely submerged, i.e. its top would be level with the surface of the water?
3. Use the table of densities to make a guess as to the composition of the unknown liquid.

Densities of materials

Metals

Metal	**ρ (g/cm^3)**
Aluminum	2.7
Brass	8.4
Copper	8.9
Gold	19.3
Iron - wrought	7.85
Iron - gray cast	7.1
Gold	19.3
Lead	11.3
Steel	7.8
Tungsten	19.3
Zinc - wrought	7.2

Woods

Balsa wood (oven dry)	0.11 ... 0.14
Ebony	1.11 ... 1.33
Oak	0.6 ... 0.9
Pine - white (oven dry)	0.35 ... 0.50

Liquids

Alcohol, Methyl	0.8
Carbon Tetrachloride	1.6
Water	1

Stone

Granite	2.7
Limestone	2.7
Marble	2.6 ... 2.8
Mica schist	2.6
Sandstone	2.1 ... 2.3