PHY/ENS 119 EXPERIMENT NO. 5: STATIC PROPERTIES OF FLUIDS

Introduction

In this laboratory, we will study certain static properties of fluids.

First, we will determine the volume V and mass m for each of several objects (solid brass and aluminum cylinders), and from this information, find the average density ρ of each, using the definition

$$\rho = m/V.$$

Second, we will then immerse the cylinders in water, and test Archimedes' principle, which states: *"A body partially or totally immersed in a fluid will be buoyed up by a force equal to the weight of the displaced fluid."* This means that objects, when weighed underwater, should weigh less than they do in air.

Third, we will study an application of the barometric formula,

$$\Delta p = \rho g h,$$

which relates the increase in pressure Δp in a fluid of (constant) density ρ at a depth h relative to the pressure at $h = 0$.

DENSITY AND ARCHIMEDES' PRINCIPLE

Procedure

1. First we will determine the volume of each of two metal cylinders (one brass, one aluminum), using four different measuring instruments. First use a ruler to measure the length L and diameter d of each cylinder. Then repeat the process using a vernier caliper, and finally do the measurements with a micrometer. Be careful to record realistic estimates of the uncertainty in each case. Using your values of L and d, determine the volume V (and its uncertainty) of each cylinder for each set of measurements. The relationship between V, L and d is

$$V = \pi L d^2/4.$$

Now measure V directly by immersing each cylinder in a graduated cylinder partially filled with water and observing the rise in water level. What is the uncertainty in V in this case?

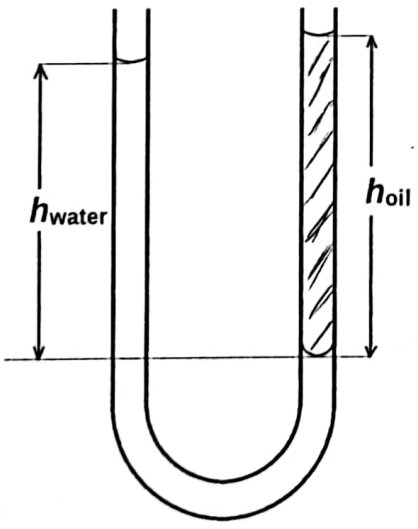
Q1. ***How do your uncertainties in V compare with each other? Which method is best? Do your values of V agree with each other, to within their respective uncertainties?***

2. Measure the mass m of each cylinder using an electronic scale. What are the weights of each cylinder?

3. Determine the density of each cylinder, using the relation $\rho = m/V$.

4. Now weigh each cylinder underwater. Is the apparent weight less than the "true" weight (as measured in air) by the weight of the displaced water, as Archimedes' Principle says? To answer this, you need to know the volume of the displaced water, and the corresponding weight of that volume of water. To make the comparison meaningful, you must include uncertainty estimates.

5. Now observe the height of the two columns of liquid in the manometer provided. The blue liquid is dyed water (for easy visibility), and the other liquid is vegetable oil. By making appropriate measurements, determine the density of the oil, using the fact that water has a density of 1000 kg/m^3. What is your uncertainty?



Manometer