Experiment 10: Archimedes' Principle

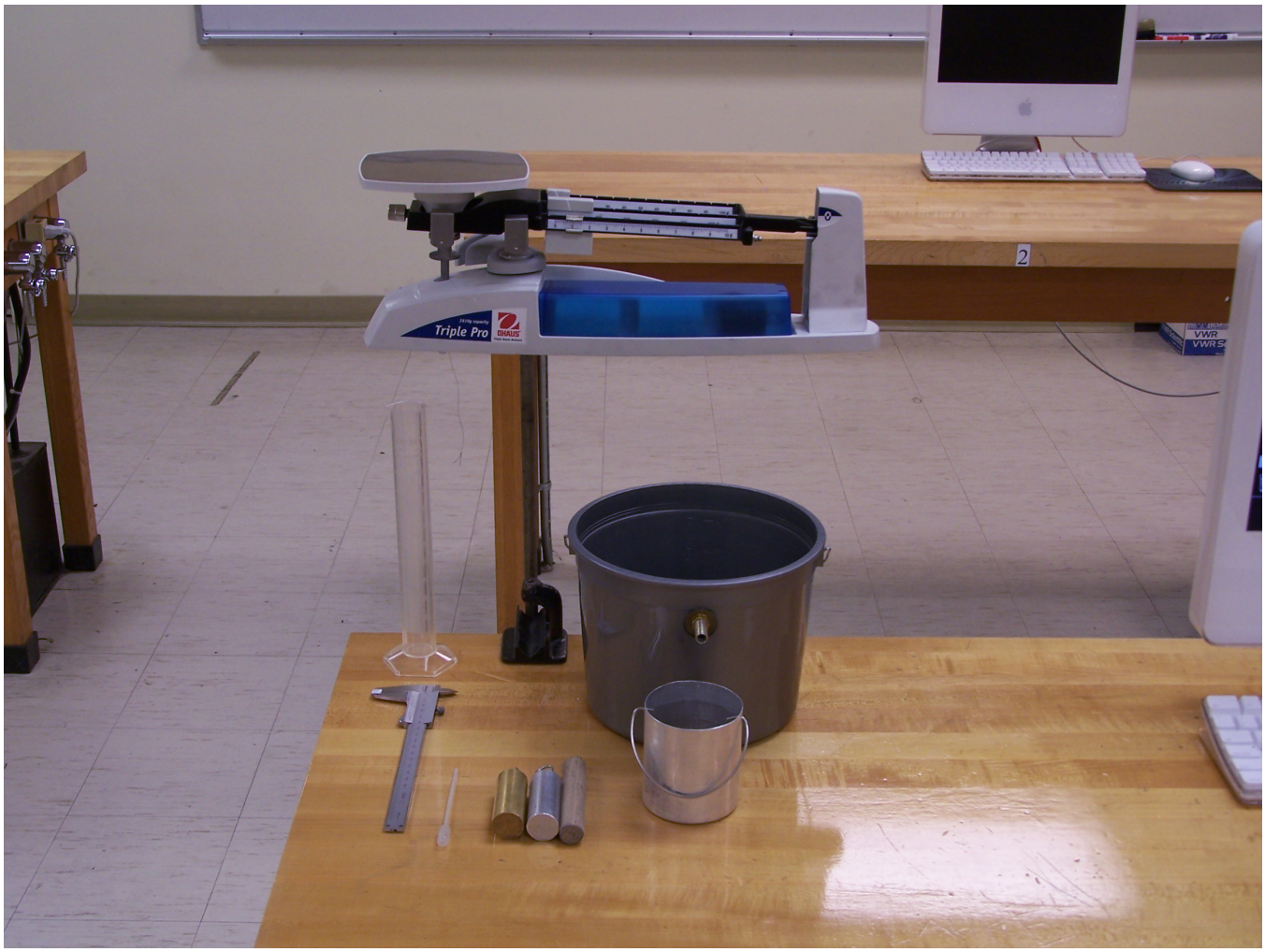

Figure 10.1

EQUIPMENT

Triple-Beam Balance with string
Graduated Cylinder
Pipette
Cylinders: (2) Metal, (1) Wood
(*Note: The cylinders have sharp hooks*)
Overflow Container
Spouted Can
Digital Balance
(2) 123-Blocks
Wood Board/Block
Rod & Clamp
Paper Towels
Water

Advance Reading

Text: Archimedes' principle, buoyant force, density

Objective

The objective of this lab is to investigate the buoyant force acting on a variety of objects, the density of the objects, and the density of our tap water.

Theory

Archimedes' principle states that a body wholly or partially submerged in a fluid is buoyed up by a force equal in magnitude to the weight of the fluid displaced by the body.

It is the buoyant force that keeps ships afloat (object partially submerged in liquid) and hot air balloons aloft (object wholly submerged in gas). We will investigate the buoyant force using the following methods:

- Direct Measurement of Mass
- Displacement Method

When an object is submerged in water, its weight decreases by an amount equal to the buoyant force. The **direct measurement of mass** will measure the weight of an object first in air, then while it is submerged in water. The buoyant force, F_B, is equal to the weight in air (F_g) minus the weight in water, $F'_g = m'g$:

$$F_B = F_g - F'_g \tag{10.1}$$

The **displacement method** requires measurement of the volume of fluid displaced by the object. The weight of the fluid displaced is equal to the buoyant force exerted on the object. Thus, the buoyant force is given by:

$$F_B = \rho g V \tag{10.2}$$

where ρ (Greek letter, *rho*) is the density of the fluid displaced, V is the volume of fluid displaced by the object, and g is the acceleration due to gravity.

The following exercises will be informative, as both floating and sinking objects are used in this experiment.

- Sketch a free-body diagram for an object that is *floating* in water. How much water does it displace? Does it displace its volume in water? Does it displace its weight in water?

- Sketch a free-body diagram for an object that is *submerged* in water. How much water does it displace? Does it displace its volume in water? Does it displace its weight in water?

The accepted value for the density of pure water at 4°C and 1 atm is $\rho_{water} = (1000 \pm 1)$ kg/m^3. We will use this value for the density of water for *Part* **??** through *Part* **??**. That is, we assume a temperature in the lab of 4°C!

We will then experimentally determine the density of the tap water we used (*Part* **??**) and compare it to the density of water at 20°C. The density of pure water at 20°C is:

$$\rho_{water} = (998.21 \pm 0.01) \text{ kg/m}^3 \tag{10.3}$$

When comparing the experimental densities of your objects or tap water, please use Table 1.1 provided at the end of *Experiment 1: Measurement & Analysis* on Page 6.