Experiment 4

Archimedes' Principle and Density of Liquids

1. Objective

1) Use a Force Sensor Motion to measure the buoyant force of the immersed volume of the body;
2) Determine the mathematical relationship between the immersed volume of the body and the buoyant force.
3) Determine the density value of liquids, *g*, by extrapolating the buoyant force *vs*. volume of the body.

2. Applying Concept

Archimedes' principle is one of the fundamental themes of the mechanics of fluids in high school; it is described in detail in any introductory physics textbook1 and it asserts that "a body immersed, or partially immersed, in a fluid receives an upward force equal to the weight of the fluid it displaces." In mathematical terms,

$$F_{\text{up}} = \rho g V_{\text{x}}$$

where ρ is the fluid density, g the free-fall acceleration, and V_{x} the volume of the immersed portion of the body. In a partially immersed body, the fluid exerts pressure on all surfaces of the body, laterally and on the bottom [Fig. 1(a)]. Notice that the forces on the sides cancel by symmetry and the net effect of the fluid pressure is an upward buoyant force. Likewise, if the body is totally immersed [Fig. 1(b)], the fluid also exerts pressure on the top of the body, but since the pressure on the bottom will be greater than on the top (pressure increases linearly with depth in a fluid of uniform density), the result is a net upward buoyant force.

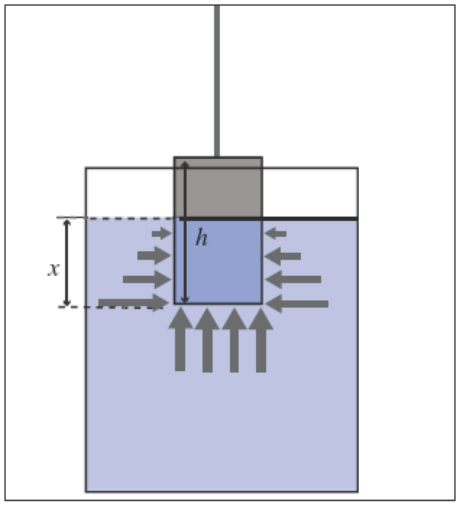

Fig. 1(a). Forces due to pressure acting on surface of partially immersed body.

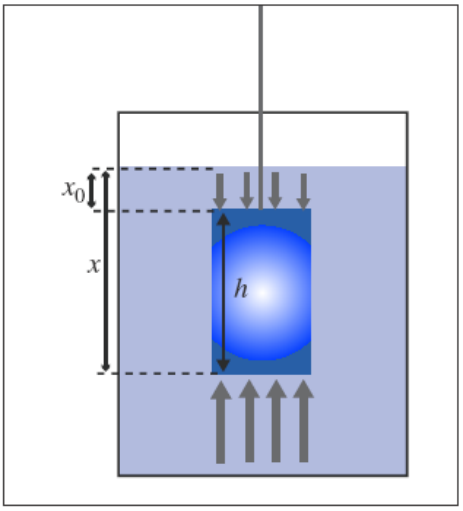

Fig. 1(b). Schematic representation of the pressure forces acting on top and bottom surfaces of a body totally immersed in a liquid.

3. Apparatus/ Materials

1) Computer
2) Vernier computer interface
3) Archimedes Law Apparatus
4) Vernier Dual-Force Sensor
5) Liquid (Water, Alchohol, Glycerin)

Reference

[1] Concetto Gianino, "Microcomputer-Based Laboratory for Archimedes' Principle and Density of Liquids," *The Physics Teacher*, vol. 46, no. 1, pp. 52-54, January 2008.