Cartesian Diver　（浮沈子）

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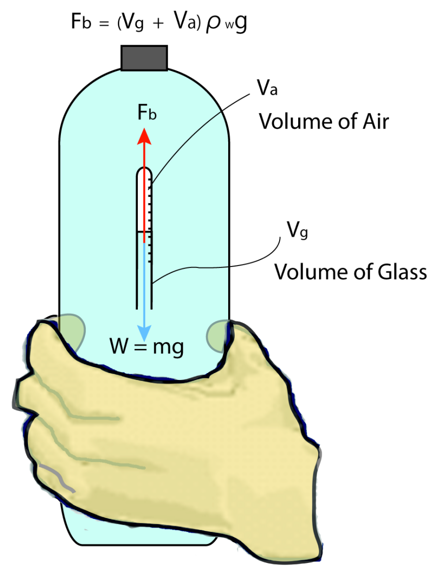

1. Objectives　Understanding buoyancy using a Cartesian driver and the Archimedes Principle.

2. Materials

Polyester bottle
Glass test tube with scale lines

3. Experimental

A Cartesian diver was made from a polyester bottle filled with water and an inverted test tube partially filled with water. As the bottle was squeezed, the diver sank. The volume of air, Va, was measured just when the diver started to sink.

Mass of glass test tube:	$m = 1.46 \times 10^{-2}$	[kg]
Volume of air in the test tube:	$Va = 8.0_5 \times 10^{-6}$	[m³]

4. Analysis

The force exerted on the tube downward = Gravity:　$mg = 1.46 \times 10^{-2} \times 9.80 = 1.43 \times 10^{-1}$ [N]

The force exerted on the tube upward = Buoyant force : $Fb = \rho Vg$ (Archimedes Principle)

ρ : The density of water = 1000 kg/m³
g:　Gravitational Acceleration = 9.80 m/s³
V:　The volume of water displaced by the test tube [m³]
$V = Va + Vg$
Va : Volume of air in the test tube:　$Va = 8.05 \times 10^{-6}$ [m³]
Vg: Volume of the glass test tube:

$$Vg = (\text{Mass of test tube})/(\text{Density of glass}) = 1.46 \times 10^{-2}/2500 = 5.84 \times 10^{-6} \quad [m^3]$$

Buoyant force:　$Fb = \rho Vg = 1000 \times (8.05 \times 10^{-6} + 5.84 \times 10^{-6}) \times 9.80 = 1.36 \times 10^{-1}$ [N]

5. Discussion

Numerical uncertainties come from the measurement of the air volume in the test tube and the density of glass: the density data, 2500 kg/m³ is from literature and it can depend of the kind of glass. Considering the uncertainties, the significant figures must be two.

Therefore, the two forces are in equilibrium as follows:

The force exerted on the tube downward = Gravity:　mg = 0.14 [N]
The force exerted on the tube upward = Buoyant force : Fb =0.14 [N]