Course and Section________ Names ______________________________

Date____________ _____________________________________

ARCHIMEDES' PRINCIPLE EXPERIMENT

Short Description:

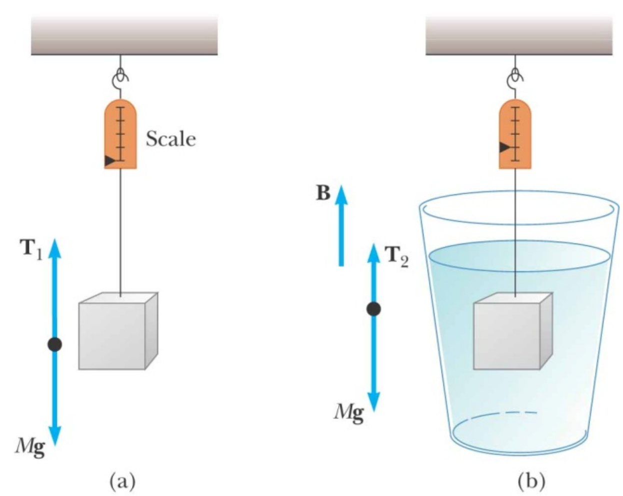
Archimedes' principle states that an object submerged in a fluid is buoyed by a force that is equal to the weight of the displaced fluid. In this lab, you are to do two experiments involving Archimedes' principle involving 1) a metal block submerged in water and 2) a helium-filled balloon.

Equipment: Vertical long rod, clamp, force sensor, metal block+string, plastic beaker, balance plastic cup, balloon, small weight, He tank (machine shop), water.

PART 1: Density of Aluminum (or copper)

Preliminary questions

1. A the metal object is suspended by a string from a spring scale (the force sensor) which measures its weight. What is the weight of the object W_a in case (a) ?



What is the weight of the object W_b in case (b) ?

What the difference of the two weights is equal to?

2. A beaker partly filled with water sits on a balance. Now a piece of aluminum is lowered into the water and held by a string (with your hand for example) so that it does not touch the bottom of the beaker. No water overflows. Does the weight measured by the balance go up, go down, or stay the same?

Procedure A (for preliminary question 1)

Set up DataStudio with the force sensor and display a graph of *force* vs. *time*. Zero the force reading by pressing the tare button on the side. Next, hang the metal (either aluminum or copper) from the force sensor and record the weight of the metal for a few seconds. Then place the metal into the cup of water until it's submerged. (Place the cup on the table and adjust the height of the force sensor so the block doesn't touch the bottom of the beaker). Stop the measurement, and find the average reading in "air" and in the "water":

$Weight_{air}$______________ $Weight_{water}$______________

What is the physical meaning of the difference of these two readings?

Numerical value of the difference: ________

Now find the density of the metal from the knowledge of its weight (in air), the buoyant force and the density of water ρ_{water} = 1,000 kg/m^3

ρ_{metal} = __________

How does your measured density compare with the accepted value?

Procedure B (for preliminary question 2)

Use the beaker with water, the balance and the metal block, no force sensor. Measure the weight of the baker (with the water in it) using the balance. Next, holding with your hand the string, suspend the metal block into the beaker sitting on a balance. Does the weight of the beaker change when the metal is submerged?

W_{Beaker} __________ $W_{Beaker+Block}$ __________ (with the metal inside)

By how much? Express the difference in Newton.

$W_{Beaker+Block} - W_{Beaker}$ _________ Which force does this difference represent?

How does this number compare with the results from Procedure A?

Question: Would your result be different if you lowered a piece of copper, *of the same volume*, instead of aluminum into the water? Explain.

PART II: Lifting capacity of a helium-filled balloon

The lifting capacity of a helium-filled balloon is given by the difference of the buoyant force acting on it and the weight of the helium in the balloon. If an object is suspended by a string from the balloon floating in air at a constant height, then the lifting capacity is:

$$F_B - W_{He} = m_b \cdot g + m_s \cdot g + m_o \cdot g \qquad (1)$$

where $F_B = \rho_{air} \cdot V_b \cdot g$ and $W_{He} = \rho_{He} \cdot V_b \cdot g$, where m_b denotes the balloon mass, m_o stands for the mass of the hanging object and m_s is the mass of the string (you can neglect it). V_b denotes the volume of the balloon, ρ_{air} is the density of air and ρ_{He} that of He gas. Hang a small mass m_o from the balloon such that it floats in air without rising or falling. You can use paperclips or whatever object you prefer. After equilibrium is reached, remove the hanging mass m_o and measure it with the scale. Record m_o and m_b as well by weighing a similar uninflated balloon (or ask to the TA for the weight of the balloon)

m_o____________ m_b _____________

Calculate the net weight in Newtons, the right hand side of equation (1): _______________

Estimate the volume of the balloon using a ruler and assuming the balloon is a sphere.

V_b = _______

The density of helium is $0.179\ kg/m^3$ and the density of air is $1.29\ kg/m^3$. Now calculate the lifting capacity (in Newtons), the left hand side of equation (1): ____________

How does the calculated lifting capacity compare with the net weight of the load?

Question: How many helium filled balloons like the one you used in this lab would be required to lift you into the air?