Static Fluids

March 11, 2011

This lab is a "station" lab. Scattered about the room are three different experiments that involve various aspects of fluid phenomena. Over the course of the lab time, circulate through all of the experiments and try them all. You do not need to do the experiments in any particular order, so feel free to skip around to empty stations.

Archimedes Principle

Archimedes principle states that the buoyant force on an object is equal to the weight of the liquid displaced by that object. In this experiment, we would like to test Archimedes principle by measuring the forces on a 0.5 kg mass that is suspended in a beaker of water. Suspend a 0.5 kg mass from the raised balance, and then slide the weights to balance the scale. Record the mass of the hanging mass as determined by the balance (it should be very close to 500 grams), and compute the associated upward force on the hanging mass provided by the balance.

Mass reading of the balance: ______________________________

Force on mass from the balance: ______________________________

Now fill a $100ml$ beaker with a known quantity of water, and submerge the hanging mass in the water. You may want to put the beaker of water on a lab jack and slowly raise it until the hanging mass is completely submerged. Readjust the sliding weights on the balance to measure the new "effective mass" of the hanging mass. Record the new mass as measured by the balance, and compute the corresponding upward force provided by the balance. Also note the volume of water displaced.

New mass reading of the balance: ______________________________

New force on mass from the balance: ______________________________

Volume of water displaced by mass: ______________________________

Draw a free-body diagram of the hanging mass before and after it was submerged in the water.

Using the directions you showed in this diagram, the size of the forces you measured above, and the acceleration of the mass you observed to calculate the size of the buoyant force on the hanging mass when it is submerged.

Now it is time to test Archimedes principle. Calculate the weight of the water displaced by the mass. It may be helpful to know that the density of water is $1g/ml$. How does this weight compare to the buoyant force you calculated in the previous question? Is Archimedes principle correct?

Magdeburg Hemispheres

In our lab is a pair of Magdeburg hemispheres. Put them together and evacuate the space inside using a vacuum pump. Close the valve, disconnect the pump, and try to pull them apart. Estimate the force exerted by you (or your partner) in attempting (or succeeding) to separate the hemispheres. Remember that one Newton is equal to 0.2248 pounds of force.

Assuming a complete vacuum inside, calculate the force required to pull the hemispheres apart. It will be equal to the cross-sectional area of the hemisphere times the atmospheric pressure. Note that the air pressure in the lab is about one atmosphere, or 1.0313×10^5 Newtons per square meter. Compare your estimated force with your calculated value.

The Bell Jar

The bell jar provides an environment in which to experiment with different objects' reaction to low pressures. Please be careful not to spill liquids (or solids) into the hole on the base stand. The vacuum pumps are not rated for this kind of load. Place the tied balloon and a fresh marshmallow under the jar and pump it down. Watch the marshmallow carefully and compare your observations to the balloon. Note also what happens when you depressurize the jar. Can you explain the behavior of the balloon and the marshmallow? What would happen if a diver surfaced without exhaling?

Now place three half-full beakers of liquid under the jar. Use hot water, cold water, and a carbonated beverage. As you pump down the jar, note any changes in the three liquids. Can you explain what you see?