Buoyancy

In this experiment you will investigate factors that might affect the amount of buoyant force that acts on a solid object that is partially or completely submerged in a liquid. Specifically we will investigate the roles that the volume submerged, the density of the submerged object, and the density of the liquid play in determining the buoyant force on an object.

Prior to performing this experiment, write a hypothesis to address each of the following questions:

1. How does changing the volume of an object that is submerged in a fluid affect the buoyant force on the object.

2. How does changing the density of the object that is immersed in a fluid of constant density affect the buoyant force on that object.

3. How does changing the density of the fluid in which an object of constant density is immersed affect the buoyant force on the object.

For this experiment, we will determine the buoyant force by measuring the “weight” of an object in air, and then measure the “weight” when it is immersed in the fluid. The difference in these two “weight” readings will be taken as the upward force acting on the object in the given situation.

In the space to the right, sketch a force diagram to represent the forces on the object. In the space below, interpret the force diagram and show how you will determine the magnitude of the buoyant Force, \( \vec{F}_B \).
In this experiment, you will examine the factors that determine the buoyant force acting on an object. Specifically, you will be immersing various cylindrical rods in various fluids and measuring how the buoyant force changes as the volume of the rod that is submerged increases. The equipment setup for this experiment is shown in the photograph below.

You will test the buoyant force vs. volume of fluid displaced relationship for each of four different rods in each of three different fluids. The fluids you will use are saturated salt water, tap water, and isopropyl alcohol. The rods you will use are made of brass, aluminum, high density polyethylene (HDPE), and polyvinyl chloride (PVC).

You will collect a total of 12 sets of data, with each rod immersed in each fluid. It is suggested that you choose a given fluid, and test all four rods in that fluid before moving to the next fluid.

You will need to collect the data necessary to determine the density of each fluid and the density of each rod.

When you begin a test with a given fluid, start with approximately 70 ml of fluid in the graduated cylinder. You will be measuring the buoyant force provided by the fluid by measuring the difference between the force reading when the object is in the air and the force reading when the object is partially submerged in, and therefore displacing some of the fluid. The volume of the fluid displaced is the difference between the volume of the fluid (as measured by the graduated cylinder) before the rod is immersed and the volume of the fluid after the rod is immersed. Change the volume of the rod submerged in increments of 2.0 ml. Continue this until the rod is completely submerged, but is not touching the bottom of the graduated cylinder. Why is it important not to allow the rod to touch the bottom? Please note that the force probe has a resolution of 0.006 N. It is recommended that you record the force reading to the nearest 0.01 N.

Be sure to thoroughly rinse and dry each rod, beaker and graduated cylinder when you have finished using it. The isopropyl alcohol and the saltwater should be returned to the stock bottles when you are done with your sample. The water can be dumped in the sink.
When you have collected all 12 sets of data, enter the data into a single LoggerPro file as 12 separate data sets. The $F_{\text{buoyant}}$ vs. $V_{\text{displaced}}$ graphs you should produce from the twelve data sets should include the following:

One graph with the plots of Buoyant Force vs. Volume submerged for all four rods in a given fluid.

One more graphs with the plots for all four rods in each of the other fluids.

One graph with the plots for one rod in all three fluids.

One more graphs with the plots for each of the other rods in all three fluids.

When you are done you will have 7 graphs, three of which will have four plots each, and four of which will have three plots each. Each graph should have a legend which makes it clear which rod or fluid corresponds to each plot. Each graph should have a title which makes the parameters of that graph clear.

When you have finished analyzing each of the seven graphs, you should be able to draw conclusions as to the relationship between:

a. buoyant force and the volume of fluid displaced.

b. buoyant force and the density of the fluid in which it is submerged.

c. buoyant force and the density of the rod that is submerged in a given fluid.

Think about, and make error calculations based on, the slope of each graph. Use unit analysis and consider the values held constant in the experiment during this process.