Fluid Mechanics

Purpose:
In this lab will explore three fundamental concepts of fluid mechanics, namely the equations of continuity, Bernoulli's equation, and Archimedes principle.

Equipment:
- 2-liter Soda Bottle
- Meter Stick
- Small Nail or other Plug

Theory:

$$A_1 v_1 = A_2 v_2 = \text{constant} \quad \text{(equation of continuity)} \qquad \textbf{Eq. 1}$$

$$P_1 + \frac{1}{2}\rho {v_1}^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho {v_2}^2 + \rho g h_2 \quad \text{(Bernoulli's equation)} \qquad \textbf{Eq. 2}$$

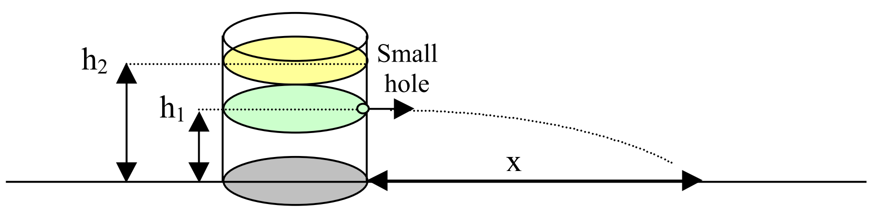

Figure 1

In the first part of this lab, you will be working with a common container (a 1 or 1.5 liter water bottle). A small hole of area A_1 is punched in the side of the bottle, a distance h_1 above the bottom. The water level is at h_2 where the cross sectional area of the bottle is A_2. When the hole is opened, the water streams out of the hole and travels a distance x before striking the ground. Your goal in this section of the laboratory is to show that the equation of continuity, combined with Bernoulli's equation predict the correct velocity for the emerging water, which can be measured using the same techniques as for an ordinary projectile fired horizontally from a height h_1 and traveling a distance x.

Experiment:
1. Keeping hole plugged, fill the bottle with water and close the cap. Set the bottle on a level surface (outside!) and unplug the small hole. Without making any measurements, determine if the speed of the emerging water is increasing or decreasing.
2. Explain the reasons behind your results.

3. Now plug he hole, and adjust the volume of water until the water level is below the tapered part of the bottle. Measure the height of the water, h_2.
4. Now unplug the hole and measure the distance the stream of water travels, x, and its uncertainty, δx using a meter stick. You will need to do this quickly, before h_2 changes noticeably.
5. Using the equations of projectile motion, determine the measured speed of the water exiting the bottle, v_1 *measured*.
6. Using Eqs. 1 and 2 above, and any measurements you need to make, determine the predicted speed of the water. Explain any assumptions you need to make in determining this value, v_1 *predicted*. Determine if the predicted and measured values agree with one another within the experimental uncertainty.

7. Now repeat this procedure for two additional heights h_2. Do your measured and predicted values of the water's initial velocity agree within the uncertainty for all three heights? If not, check your measurements and repeat. If they still don't agree, consider your assumptions—are they correct?