Name: _____

Date: _____

Physics Laboratory Exercise: The Bernoulli Effect

Background Information

The Bernoulli Equation states that for a fluid with very low viscosity flowing in a pipe,

$$p_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = p_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$$

For fluids flowing out of a large container, in your report you need to **show** that the velocity at the exit point is given by a special form of the Bernoulli Equation:

$$v = \sqrt{2gh}$$

And in your report ***you also need to show that*** the flow rate is given by:

$$R = \frac{V}{t} = A\sqrt{2gh}$$

In an ideal case where we can assume the velocity of exiting fluid is constant, the time to empty a given volume is:

$$t = \frac{V}{A\sqrt{2gh}}$$

Materials

In addition to the usual paper, pencil, and calculator, this lab requires the following materials:

- 5 gallon bucket with a small ¼-inch hole drilled in the bottom, and a stopper for that hole
- About 5 gallons of tap water
- Bottle with volume marks
- Ruler
- Stopwatch

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Step 1: Setup

Set up the provided equipment as illustrated then fill the bucket with water.

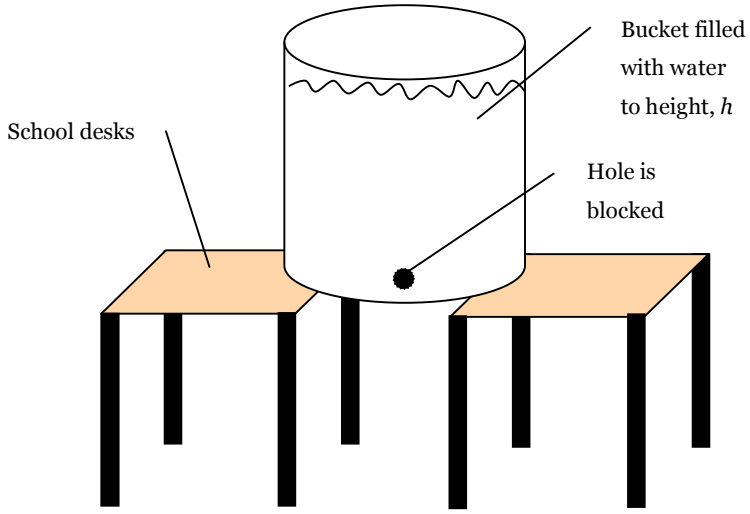

Figure 1: Initial setup of lab exercise equipment.

The bucket has a hole at the bottom that was created with a ¼" drill bit. That's ¼" in diameter. When calculating area of the hole, assume a ¼" diameter.

Step 2: Experiment

Place the small bottle with volume marks beneath the opening in the bucket then remove the stopper. Start the stopwatch. When the volume in the small bottle reaches **16 ounces**, stop the stopwatch and **replace the stopper**. Record the time elapsed. Repeat for a total of six tests. – While the fluid is flowing, use your cellphone camera (or any other camera) to **take a close-up picture** of the fluid stream as it exits the bucket.

Volume emptied = 16 ounces
Height of water (h) = 3 inches

	1st Run	2nd Run	3rd Run	4th Run	5th Run	6th Run
Time to empty (t_{actual})						

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Step 3: Calculate

Calculate the theoretical amount of time it will take to empty **16 ounces** from the bucket of water.

Volume emptied (V) = 16 ounces ÷ 998.83 ounces/ft^3 = _____

Area of drain hole (A) = πr^2 = _____

Acceleration due to gravity (g) = 32 ft/s^2

Height of water (h) = 3 inches = _____ft_

$$t_{theoretical} = \frac{V}{A\sqrt{2gh}}$$

Theoretical time to empty volume ($t_{theoretical}$)	

Step 4: Analyze

Calculate the error between $t_{theoretical}$ and t_{actual} for all test runs.

$$Error = 1 - \frac{t_{theoretical}}{t_{actual}}$$

	1st Run	2nd Run	3rd Run	4th Run	5th Run	6th Run
Theoretical time to empty volume ($t_{theoretical}$)						
Actual time to empty volume (t_{actual})						
Error						

Assume the hole made by the ¼" drill bit isn't an accurate ¼". What is the actual diameter? To solve, rearrange the time-to-drain equation to solve for the diameter of the hole.

$$t = \frac{V}{A\sqrt{2gh}}$$

Calculated diameter (inches)	

What was the percent error in the hole's diameter?

Write the equation you use here:

Error =

Given diameter (inches)	
Calculated diameter (inches)	
Error	

By analyzing the ***shape*** of the stream leaving the bucket, find the approximate outflow ***speed***, and include this in your report.

[Hint: Use both the Equation of Continuity and Bernoulli's Equation.]