ENGR 4420 - Engineering Measurements
LOG SHEET REPORT
Spring 2022

LAB SECTION: 201 **Team Number: 5** **Lab No. 3**

DATE PERFORMED: February 16, 2022 **DATE SUBMITTED: March 1, 2022**

TEST PERFORMED: Torricelli Principle- Discharge of Tank Through an Orifice

TYPE OF TEST/OBJECTIVE:

Apply Torricelli principle along with Bernoulli's equation to the discharge of a tank through an orifice and compare various properties with experimental results.

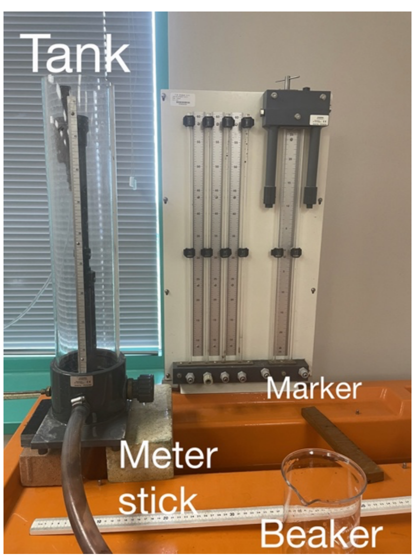
EQUIPMENT USED:

PRIMARY EQUIPMENT:
Tank - cm
Stopwatch - s
Scale- g
Beaker- mL
Meter Stick - mm

SUPPORT EQUIPMENT:
Wooden Marker

EQUIPMENT SETTINGS:
The were no preset settings when controlling the rate of water going out so it was by observation.

EQUIPMENT CONFIGURATION AND SET UP



Picture 1. Shows the tank that was filled with water and then controlled to let out water which was collected with the beaker and the wooden marker was used to mark the distance of the stream.

1. Turn on pump and fill up the tank to 5 cm above the desired water height. Start at 50 cm.
2. Have one person controlling the water rate and the stopwatch, one person collecting the water and one person placing the wooden marker at the distance of the stream.
3. The person controlling the stopwatch will start the time when the water level reaches the desired height and will stop the time after 5 cm.
4. During this time the person will place the wooden marker at the maximum distance the stream traveled and will measure it with the meter stick.
5. The person collecting the water will collect water for the start of the time and stop after 5cm.
6. Measure the volume of the water using the beaker and weight the beaker.
7. Record all findings on Table 1.
8. Repeat steps 1-7 for 8 trials.

SAFETY MEASURES:

Wear Safety glasses.
Wash hands if there is any contact with the water.

FINDINGS and OBSERVATIONS:

Lab was conducted February 16, 2022, where Lorryn Berry and Edgar Diaz were present. The T.A. was present and helped the group since Xueying Chen was self-isolating and not able to attend the lab.

The hardest part of this experiment was to maintain the rate of water consistent in every trial while also starting and stopping the timer. Some trials were faster than others which led to some errors in our table and our graph as the times were not consistent. There was also some error with the person collecting the water with the beaker starting at the same time with timer and person controlling the water flow. The team had to redo one trial because there was a problem with the timing of the trial.

For the theoretical part of the experiment we started with Bernoulli's which is:

$$p_1 + \frac{1}{2}(rho)v_1^2 + (rho)g(y_1) = p_2 + \frac{1}{2}(rho)v_2^2 + (rho)g(y_2)$$

Where p is the pressure, rho is the density, v is the velocity, g is gravity and y is the vertical height from datum.
Since the equations a constant the exit velocity can be found with the equation:

$$v_c = \sqrt{2g(H-h)}$$

Where g is gravity, H is the height of the water and h is the height of the spout from the datum.
For the experimental part of the experiment we used kinematics equation to find that:

$$V_e = \frac{horizontal\ distance}{elapsed\ time}$$

In theory the exit velocity from projectile motion and from mass flow rate in Table 1 should be similar. However, there is an error since the exit velocity from projectile motion depends on the elapsed time and the team's time was not consistent. Since the volumetric flow depends on the exit velocity which is inaccurate from the elapsed time in the projectile motion it is very different from the volumetric flow using the captured mass of the water.

DATA TABLE and GRAPH

Experimental Data								
Trial	Height (m)	Horizontal Projectile (m)	Captured mass (g)	Mass Flow Rate (g/s)	From Projectile Motion		From Mass Flow Rate	
					Exit Velocity (m/s)	Volumetric Flow (m^3/s)	Exit Velocity (m/s)	Volumetric Flow (m^3/s)
1	0.45	0.44	407	19.76	0.0214	1.883E-07	2.242E+06	4.074E-04

2	0.40	0.37	369	20.20	0.0203	1.785E-07	2.291E+06	3.694E-04
3	0.35	0.352	304	32.62	0.0378	3.329E-07	3.701E+06	3.043E-04
4	0.30	0.31	326	23.32	0.0222	1.954E-07	2.646E+06	3.263E-04
5	0.25	0.285	314	23.26	0.0211	1.861E-07	2.639E+06	3.143E-04
6	0.20	0.275	314	21.58	0.0189	1.666E-07	2.448E+06	3.143E-04
7	0.15	0.201	290	23.69	0.0164	1.447E-07	2.688E+06	2.903E-04
8	0.10	0.135	265	34.42	0.0175	1.545E-07	3.905E+06	2.653E-04

Table 1: This table holds the data for all eight trials of the experimental phase.

Theoretical Data						
Trial	Height (m)	Projectile Time (s)	Horizontal Projectile (m)	Projectile Velocity (m/s)	Mass Flow Rate (g/s)	Volumetric Flow Rate (m^3/s)
1	0.45	20.60	57.643	2.798	24.6390	2.466E-05
2	0.40	18.27	47.814	2.617	23.0444	2.307E-05
3	0.35	9.32	22.578	2.423	21.3309	2.135E-05
4	0.30	13.98	30.908	2.211	19.4671	1.949E-05
5	0.25	13.50	26.685	1.977	17.4049	1.742E-05
6	0.20	14.55	24.890	1.711	15.0630	1.508E-05
7	0.15	12.24	17.073	1.395	12.2824	1.229E-05
8	0.10	7.70	7.564	0.982	8.6499	8.659E-06

Table 2: This table holds all the theoretically calculated data for all eight trials.

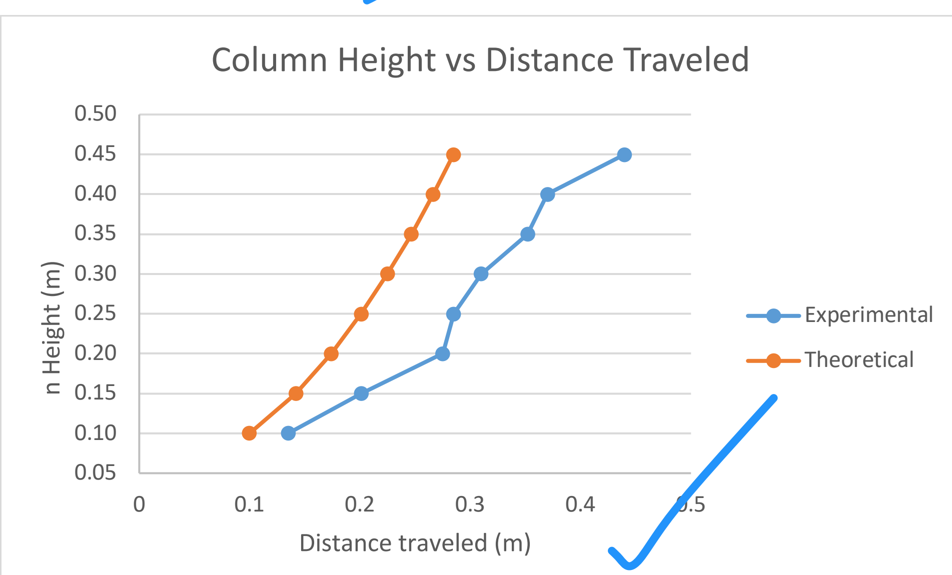


Figure 1: This graph holds the experimental and the theoretical data for the height of the water vs. the horizontal distance traveled.

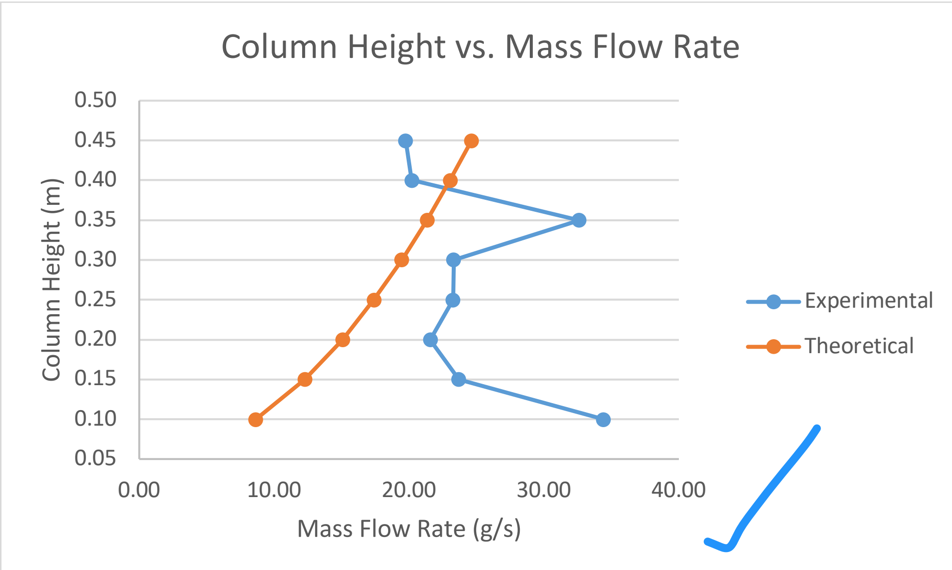


Figure 2: This graph holds the experimental and the theoretical data for the height of the water vs. the mass flow rate.

SUMMARY:

The objective in this experiment was to apply Torricelli principle along with Bernoulli's equation to the discharge of a tank through an orifice and compare various properties with experimental results. The lab was held based on lab procedures from step 1 to 8. The results expected were that experimental and theoretical value should be similar to each other. There were two sets of data collected during the experiment which are experimental and theoretical data. In experimental data, there are 8 trails with different heights, horizontal projectile, and captured mass etc. values and all data under projectile motion and mass flow rate were calculated. In table 2, horizontal projectile (m), projectile Velocity (m/s), mass flow rate (g/s) and volumetric flow rate (m^3/s) were also calculated. After all data was calculated, the two graphs were created using Excel. Figure 1 holds the experimental and the theoretical data for the height of the water vs. the horizontal distance traveled. From the graph the theoretical values are higher than experimental. In Figure 2, the experimental and theoretical data was held for the height of the water vs. the mass flow rate. From graph, it showed theoretical value is more stable increase and instead experimental value is unstable. The errors were caused by timing errors and inconsistent trials. For example, in step 2 and in step 3. These two steps are extremely easy to make errors and inaccurate data. There is also an error from the beaker since it was not a very accurate instrument to measure the volume.

APPENDIX

References
List all references used to assess the data. All reports will require references.

Team Tasks:
Lorryn Berry: Tables and graphs, equations in appendix. Xueying Chen: summary. Edgar Diaz: equipment set up, findings and observations.

CALCULATION SHEET:
Experimental-

Projectile Motion:

$$exit\ velocity = V_e = \frac{horizontal\ distance}{elapsed\ time}$$

Equation 1

$$volumetric\ flow = \frac{V_e}{A_d} = \frac{exit\ velocity}{orifice\ area}$$

Equation 2

Mass Flow Rate:

$$exit\ velocity = V_e = \frac{mass\ flow}{orifice\ area}$$

Equation 3

$$volumetric\ flow = m\left(\frac{1}{\rho_{water}}\right) = captured\ mass\left(\frac{1}{density_{water}}\right)$$

Equation 4

Theoretical-

$$horizontal\ projectile = V_e t = velocity * time$$

Equation 5

$$exit\ velocity = \sqrt{2g(H-h)}$$

Equation 6

$$mass\ flow\ rate = V_e A_d \rho_{water} = (exit\ velocity)(orifice\ area)(density\ of\ water)$$

Equation 7

$$volumetric\ flow\ rate = V_e A_d = (exit\ velocity)(orifice\ area)$$

Equation 8

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In the theoretical table the projectile time is constant t=underroot2h/g