Experiment A
Orifice and Free Jet Flow

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1 Introduction

The main purpose of this experiment is to investigate the Bernoulli equation for orifice and free jet flow. This experiment is divided into two parts, the first part is to determine the coefficient of velocity from the jet trajectory. the second part is to determine the coefficient of discharge under the constant head.

2 Theory

In Experiment A1, the basic equations are Bernoulli's (1) .

$$\left[\frac{p}{\gamma}+\frac{v^2}{2g}+z\right]_1=\left[\frac{p}{\gamma}+\frac{v^2}{2g}+z\right]_2 \tag{1}$$

As shown in the figure below, where 1 and 2 represent the surface of the reservoir and the water discharge point.

In Bernoulli's equation, because the position 1 is in contact with the air and the water surface is static, so the pressure force p = 0, and the water surface flow velocity v = 0. Similarly, the pressure at position 2 is p = 0. With the datum at 2, we only need to measure the head difference between

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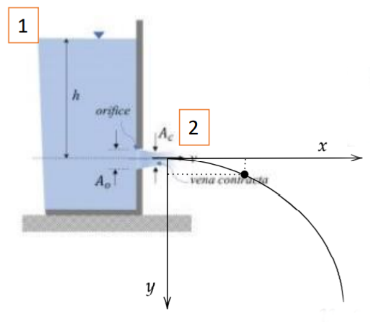

Figure 1: Experimental Demonstration

position 1 and 2, and measure the jet velocity of 2, after that put into other constants, Bernoulli's equation could be proved.

Therefore, Bernoulli's equation can be simplified.

$$v_2 = \sqrt{2gh} \tag{2}$$

Where v_2 is the water velocity in position 2, h is the head difference between 1 and 2. In fact, due to the jet vena contracta, it exists a coefficient C_v to effect the real velocity. C_v depends on the viscosity of the water, so $C_v < 1$.

The real velocity is

$$v = C_v\sqrt{2gh} \tag{3}$$

By neglecting the air resistance, the x and y position could be caculated By

$$x = vt \tag{4}$$

$$y = \frac{1}{2}gt^2 \tag{5}$$

From Equation 6, it can be caculated

$$t = \sqrt{\frac{2y}{g}} \tag{6}$$

By using equations Equation 3,Equation 4,Equation 6 we can derive

$$C_v = \frac{x}{2\sqrt{yh}} \tag{7}$$

Also can be rewrite as

$$x = 2C_v\sqrt{yh} \tag{8}$$

Hence, For a constant coefficient C_v, which can be determined from the x and y coordinates.

In Experiment A2, the continuity equation is given by

$$Q = Av \tag{9}$$

From this, we can calculate the real water flowrate.

Because the vena contracta decrease the cross-sectional area of jet flow, it also exists a coefficient C_c, which $C_c < 1$.

Hence,

$$A = C_c A_0 \tag{10}$$

$$Q = C_c A_0 v \tag{11}$$

Substitution for v from (3), the results is

$$Q_t = C_c A_0 C_v\sqrt{2gh} \tag{12}$$

Which used the discharge coefficientC_d to Substitute C_c and C_v.

$$Q_t = C_d A_0\sqrt{2gh} \tag{13}$$

This is also a linear equation with horizontal coordinates $\sqrt{h}$ and vertical coordinates Q_t. The slope S = $C_d A_0\sqrt{2g}$

3 Method

As can be seen above, It need to measure the difference in head between 1 and 2.

The head difference between 1 and 2 can be easily measured by tools such as a ruler. For the trajectory of the water jet of 2, adjusting the needle mounted on the back plate so that its bottom point is as close as possible to the upper edge of the jet, and tighten the screws.

Next, attach a sheet of paper to the back-board between the needle and board, and make sure it is horizontal and secure.

As you can see in the Figure 1, Set up the same coordinate system on the attachment sheet, and then measure the x and y distance between each marker point to get table Table **??**.

In order to ensure the accuracy of the data, four data sets were measured by using two different orifice diameters and two different heights.

The data is shown in the following table.

	X=	43	93	143	193	243	293	343	393
D=3	h=256	-1	-11	-24	-42	-63	-91	-123	-161
	h=365	-1	-8	-17	-31	-44	-65	-88	-116
D=6	h=276	-1	-8	-21	-38	-60	-88	-122	-151
	h=380	-1	-8	-16	-28	-44	-62	-84	-110

(unit:mm)

Table 1: attachment sheet recording table

In experiment A2, a measuring cylinder is a good tool to measure the flow rate of water. First, prepare an empty measuring cylinder and collect the water jet from 2 places. When the measuring cylinder starts to receive water, press the stopwatch to start timing. Wait for a period of time until the measuring cylinder exceeds 800 ml, then stop collecting water and stop timing.

h(mm)	V(ml)	T(s)
256	875	76
296	855	70
333.5	830	64
365	855	64

Table 2: record of flowrate (diameter:3mm)

h(mm)	V(ml)	T(s)
256	875	76
296	855	70
333.5	830	64
365	855	64

Table 3: record of flowrate (diameter:6mm)

4 Results

5 Analysis

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6 Conclusion

The conclusion should, as the abstract, wrap up what you have found in the experiment. It should state what you have done and what you have found. The conclusion should only state what is obvious from the discussion in section 4; no new information should arise here. The conclusion is the first place the reader will go looking if he wants to get an overview of the report. If it is interesting, he might read the rest. Be sure that the conclusion is short and concise, but do not omit important information. You have one shot at presenting your results: if you have done excellent work at the lab it doesn't matter if you are unable to present the results in an appealing way. The report is your only way of communicating and presenting your hard work.