**American University of Beirut**

**Experiment # 1:**

**Orifice Discharge**

Experiment Date: 14/12/2010

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# Abstract

We aim to calculate the discharge coefficient $C\_{d}$ for an orifice tank based on an equation derived from the continuity equation.

We repeated the experiment twice: once with a 3mm orifice and the other with a 6mm orifice. We wanted to see the effect of the size of the orifice on $C\_{d}$.

# Apparatus:



# Procedure:

We fill a tank with water to a height slightly larger than 40cm. We then empty it through an orifice that has a diameter of 3mm.We start the timer when the water level reaches 40cm and take note of the time every drop of 2cm. When we reach h=2cm we start recording the time every 0.5cm drop in water level, until it reaches a height h=0.5 cm.

The experiment is repeated another time using an orifice with a diameter of 6mm.

# Theoretical Background

Equations to be used are:

 



# Detailed Derivation of the equations

For the upper part:













At t=0, h=:









With

 

# Collected Data

|  |  |  |
| --- | --- | --- |
| $$\sqrt{h}$$ | 3mm-Orifice | 6mm-Orifice |
| 0.707 | 448 | 105 |
| 1.000 | 433 | 102 |
| 1.225 | 429 | 100 |
| 1.414 | 424 | 97 |
| 2.000 | 401 | 93 |
| 2.449 | 376 | 91 |
| 2.828 | 354 | 86 |
| 3.162 | 333 | 81 |
| 3.464 | 316 | 76 |
| 3.742 | 299 | 72 |
| 4.000 | 285 | 69 |
| 4.243 | 257 | 62 |
| 4.472 | 229 | 55 |
| 4.690 | 203 | 49.8 |
| 4.899 | 176 | 43 |
| 5.099 | 152 | 35 |
| 5.292 | 128 | 30.1 |
| 5.477 | 105 | 28.8 |
| 5.657 | 83 | 19.6 |
| 5.831 | 61 | 14 |
| 6.000 | 46 | 9.5 |
| 6.164 | 19 | 4 |
| 6.325 | 0 | 0 |

# Graphs of t vs. $\sqrt{h}$

# Calculated slopes and $C\_{d}$

For upper part:

$$slope= \frac{t\_{0}-t\_{x}}{\sqrt{H\_{0}}-\sqrt{h\_{x}}}$$

$$slope=-\frac{2}{C\_{d}\sqrt{2g}}× \left(\frac{D\_{CYN}}{D\_{ORF}}\right)^{2} ;$$

$$C\_{d}=-\frac{2}{slope \sqrt{2×9.81}}×\left(\frac{13.7}{D\_{ORF}}\right)^{2}$$

For lower part:

$$t\_{lower}= t\_{H\_{0}\rightarrow H\_{b}}+\frac{1}{C\_{d}\sqrt{19.62}}\frac{\left(13.7π-24\right)13.7}{πD\_{ORF}^{2}} \left(\sqrt{H\_{b}}-\sqrt{h\_{x}}\right)$$

$$slope=\frac{t\_{H\_{0}\rightarrow H\_{b}}}{\left(\sqrt{H\_{b}}-\sqrt{h\_{x}}\right)}+\frac{1}{C\_{d}\sqrt{19.62}}\frac{\left(13.7π-24\right)13.7}{πD\_{ORF}^{2}}$$

## 3 mm orifice:

Upper part:

 $slope=\frac{0-83}{0.6325-0.5657}=-1242.5$

$$C\_{d}= -\frac{2}{-1242.5×\sqrt{2×9.81}}×\left(\frac{13.7}{0.3}\right)^{2}=0.758$$

Lower part:

$slope= $-339.5

$$slope=\frac{424}{\left(1.414-0.0707\right)}+\frac{1}{C\_{d}\sqrt{19.62}}\frac{\left(13.7π-2.4\right)13.7}{π0.3^{2}}$$

$C\_{d}=$1.86

## 6 mm orifice:

Upper part:

$$slope=-293.41$$

$$C\_{d}=0.69$$

Lower part:

$$slope=-113.5$$

$$C\_{d}=2.71$$

# Discussion

## Description of results

|  |  |  |
| --- | --- | --- |
| Orifice Diameter | 3mm | 6mm |
| Upper Part | 0.758 | 0.69 |
| Lower Part | 1.86 | 2.71 |

# Analysis of Results:

We can conclude that the diameter of the orifice affects$ C\_{d}$. We expected that since the bigger the diameter the faster the water will empty out. We also noticed that for the same diameter the curve had two parts with different Cd. The upper part had a smaller Cd than the lower.