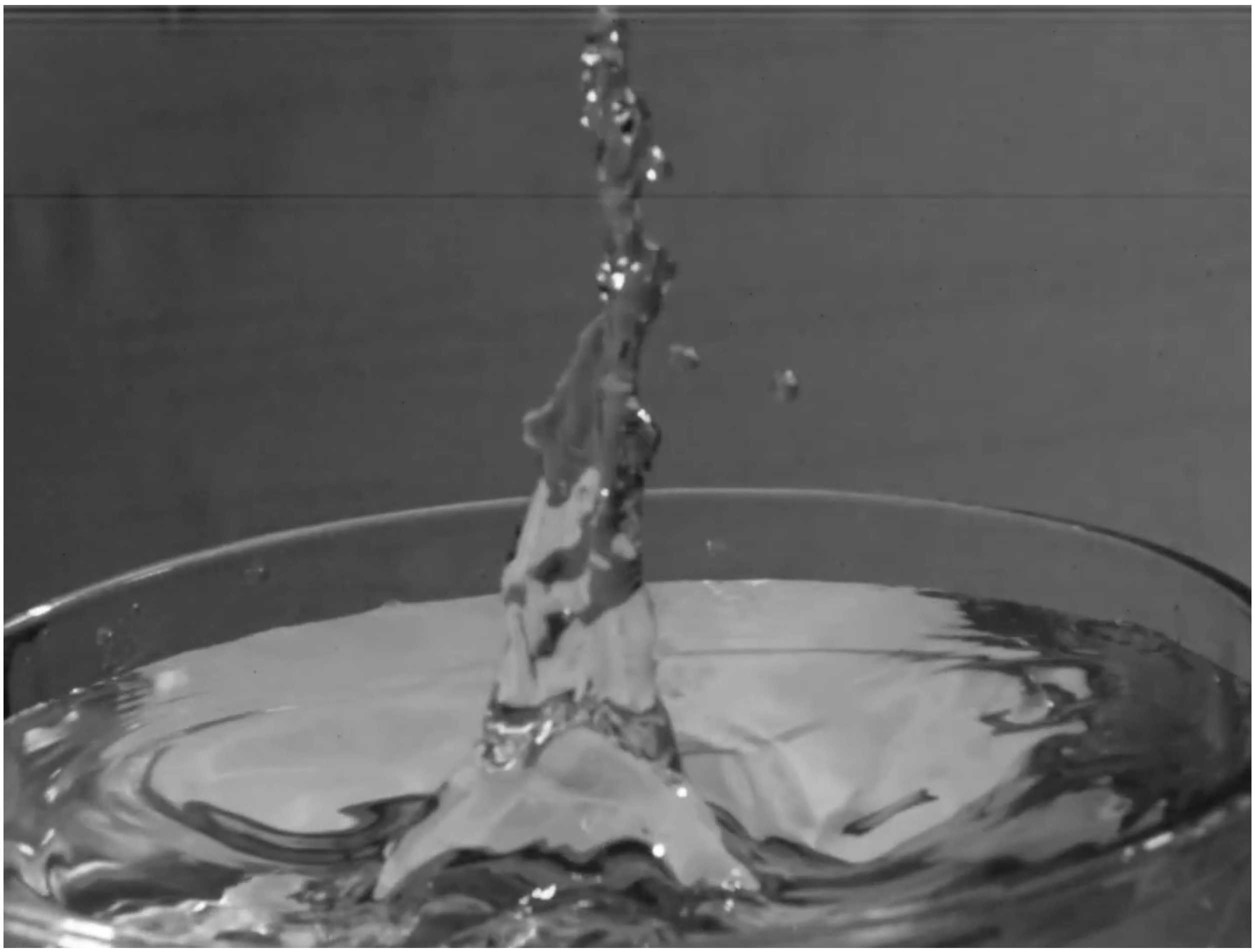
Vis 3 Report

Flow Visualization

Nathan Gallagher



I. Introduction

The goal of this visualization was to film a Worthington Jet using a Phantom Miro C110 high speed camera. This way, we could examine the physics of the jet and verify why it behaves the way that it does. As this is a fairly high speed phenomena that would be difficult to capture with a still photograph, the high speed video is key in viewing the phenomena with any sort of clarity. The final video can be viewed here: https://youtu.be/C36Famqux2k.

II. Testing Setup and Materials

The test apparatus consisted of the high-speed camera sitting on a tripod about 4-5 feet away from the subject looking down on it. We then dropped the objects from about 1 foot above the water-filled container and recorded the aftermath. The scene was lit with ambient light from outside, a ring light above the container, and a flashlight being held about two feet away from the container. The rock dropped in this particular experiment was about 3 inches long.

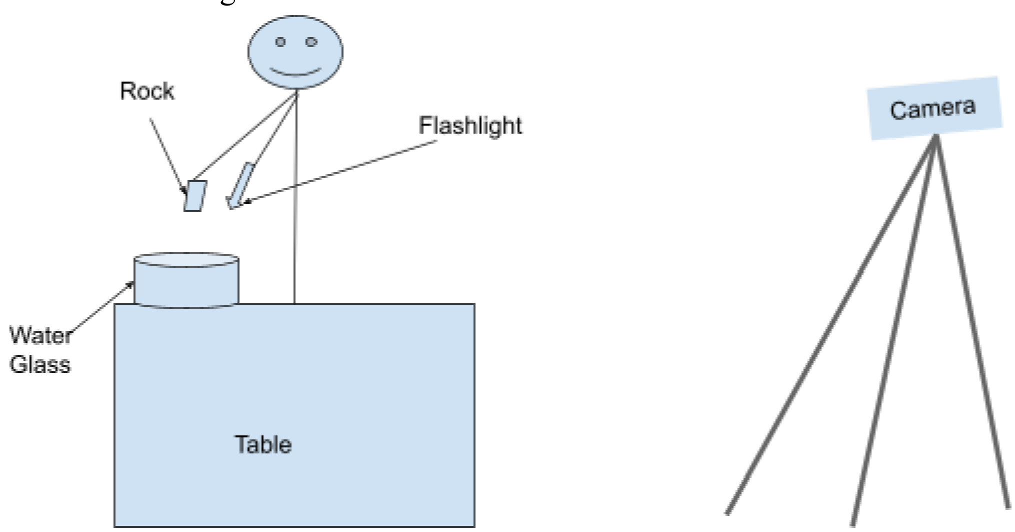


Figure 1: Experimental Setup

III. Physics Analysis

The primary physics concept illustrated in this video is that of a Worthington Jet. A Worthington Jet is the tall splash that shoots out of a body of water when an object is dropped into it. The jet forms through a multi-step process, the first of which is the object hitting the water and forming a cavity. Figure 2 shows this step in the video that we took.

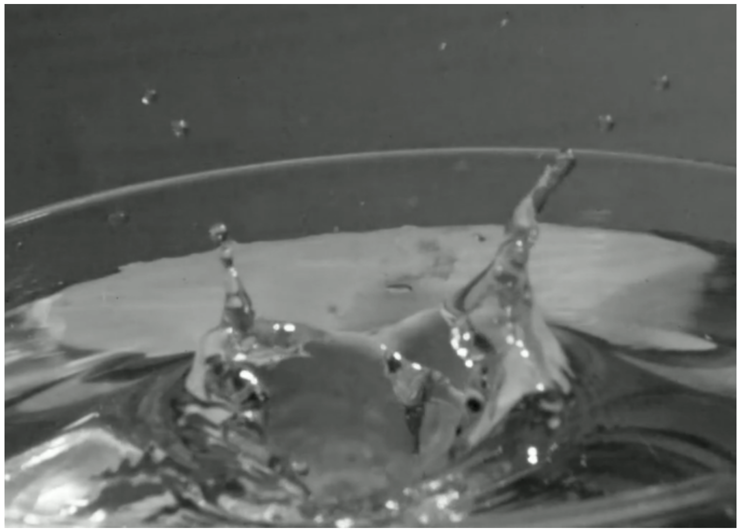


Figure 2: Image of Cavitation Process

This cavity forms thanks to the surface tension of water being strong enough to hold the water molecules together when the rock hits them. As a polar molecule, the cohesive forces between the water molecules are strong (Water Science School), so instead of the rock seamlessly breaking the surface of the water it drags a sizable portion of the water down with it as it falls. As it does so, a pocket of air forms behind the rock. As the rock travels deeper into the body of water, the pocket behind the rock will begin to close off thanks to the pressure difference between the cavity and the water around the cavity. This will cause a pocket of air to become trapped beneath the surface of the water. This stage is illustrated in Figure 3 below.

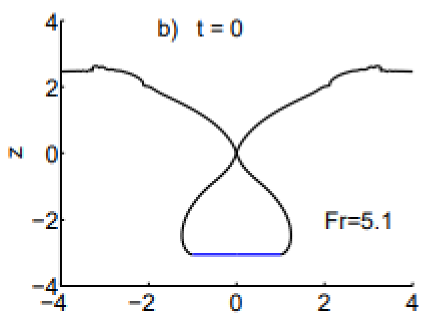


Figure 3: Formation of Air Pocket (Gekle and Gordillo)

As air is considerably less dense than water, the air in this pocket then rises upwards, pushing the water film above it upwards as well. This is what ultimately results in the tall jet of water shown in Figure 4 below.

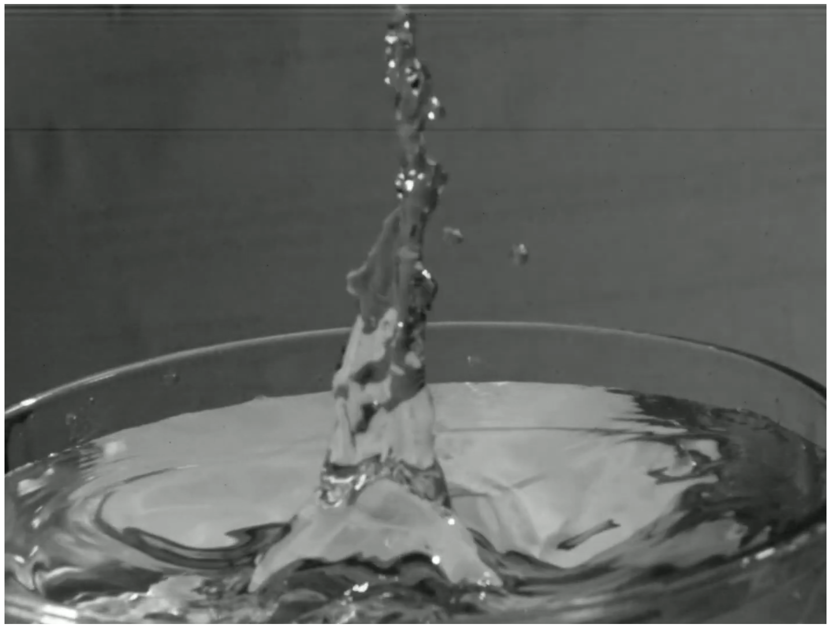


Figure 4: Fully Developed Worthington Jet After Air Pocket Rises

IV. Photographic Technique and Post-Processing

This video was taken by a Phantom Miro C110. The known camera specifications are shown in Table 2 below. Other specifications, such as the ISO, were automatically set by the camera program and are therefore unknown.

Table 2: Camera Specifications

Specification	Value
FPS	1200
Resolution	1024 x 768

The camera was about 4-5 feet away from the container. The container was lit using a ring lamp and a bright flashlight, along with some small ambient light from a nearby window above and behind the subject. In order to remove the unsightly color of the wall behind the jet, the video was brought into Minitool Movie Maker and altered to grayscale. Figure 4 and 5 below show the drastic change this makes in how appealing the video looks.

Figure 4: Raw video example

Figure 5: Final video example

V. Conclusion

I am overall very happy with how this video and image turned out. I think that, while the focus and lighting were tricky, the image came out clear and clean which I am happy about. I was also satisfied with how well you could see the cavitation and jet formation processes of the Worthington Jet. If I were to do this experiment again, I would probably try to record it from an orthogonal angle as well so that I could also see the air pocket being formed clearly.

VI. References

Gekle, Stephan, and J. M. Gordillo. *Generation and Breakup of Worthington Jets After Cavity Collapse*. 29 July 2009. *J. Fluid Mech.*, https://arxiv.org/pdf/0907.5154v1.pdf. Accessed 7 November 2022.

Water Science School. "Surface Tension and Water | U.S. Geological Survey." *USGS.gov*, 6 June 2019, https://www.usgs.gov/special-topics/water-science-school/science/surface-tension-and-water. Accessed 7 November 2022.