Team Assignment #3 Write-Up

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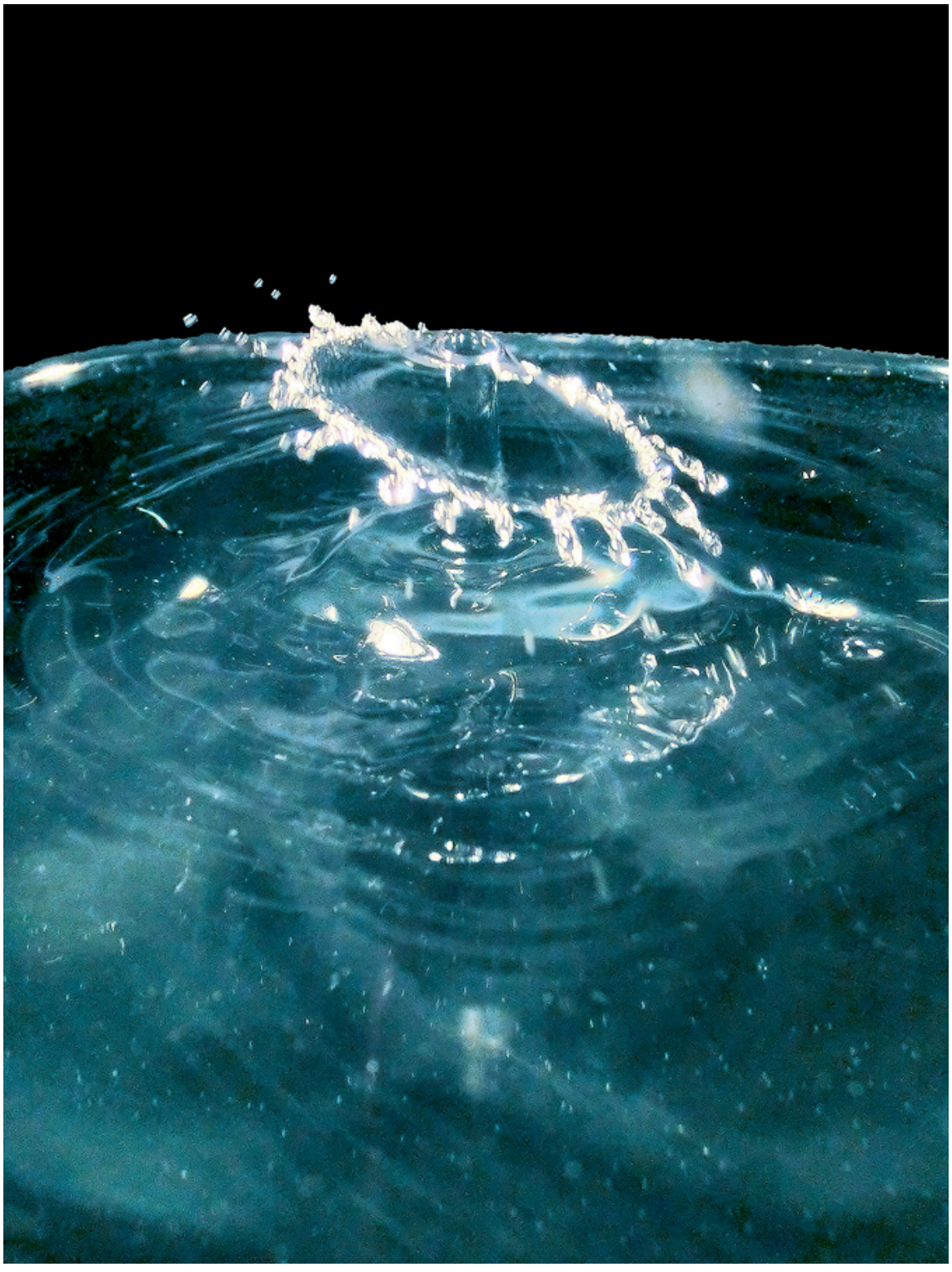
Flow Visualization – MCEN 5151

4/29/13



I. Introduction

For the third and final team assignment, I wanted to try to do something new for me. I had done simple home experiments, macro photography, time lapses, and high-speed video already, and realized that a complex experiment would be more interesting. Wayne Russell had the idea to create a precise apparatus that released two droplets at varying intervals so that the second one collided into the Worthington jet created by the first. By controlling two LED lights in the same apparatus, the collision would be illuminated perfectly. The collision of the two droplets is a beautiful, and hard to capture scene, which is why this became the goal of the team photo.

II. Flow Apparatus

The apparatus created by Wayne is shown below in Figure 1 in detail.

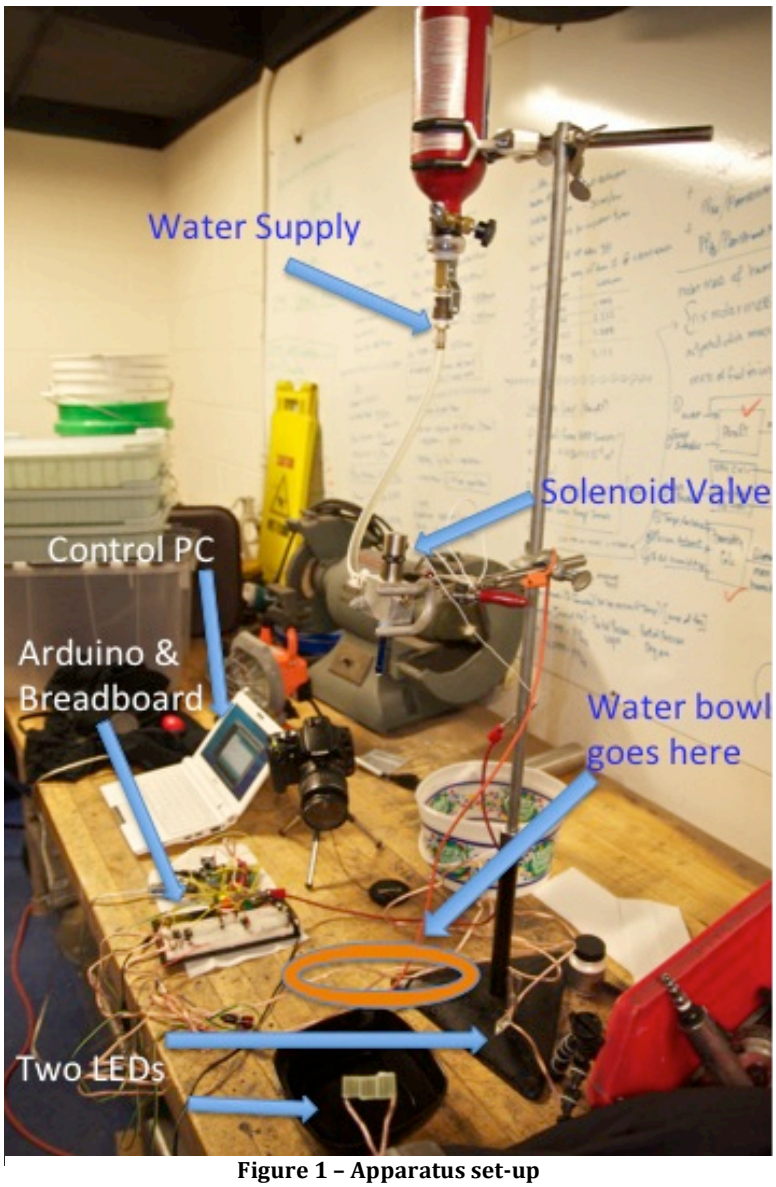


Figure 1 – Apparatus set-up

The water tank is at the highest point, held in place by a stand and allows gravity to pull the water downwards towards the solenoid valve. The solenoid valve is held by another clamp, roughly two feet above the surface of the table. The solenoid valve is controlled by an Arduino microcontroller, which is controlled by the small control PC on the left of the Figure. A signal is sent to the valve to release a drop, then there is a set delay until the second drop is released in order to control the impact of the two at the perfect spot to get the image we were all looking for. Two LED's also receive a voltage and illuminate at some delay later, when the two drops actually collide.

Coordinating the timing of this collision was one of the hardest parts. This was done with the help of Kelsey Spurr, by using high-speed video shot at 1,000 frames per second. By counting the number of frames that the collision was off and the LEDs were off, the delay in the Arduino code was adjusted.

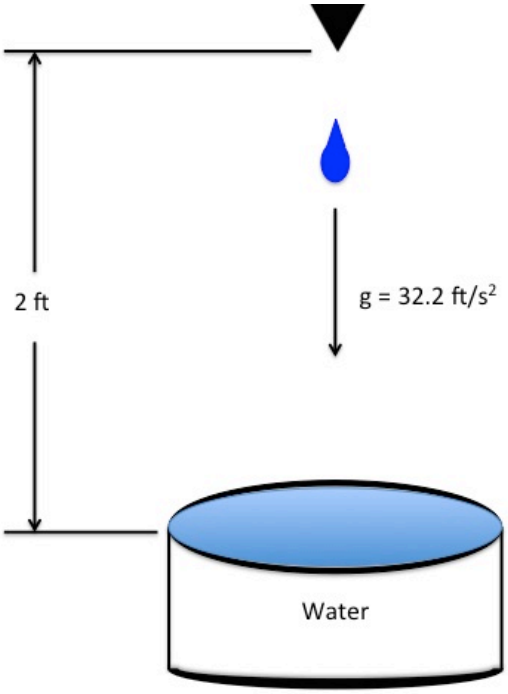


Figure 2 – Droplet path diagram

Since the water droplets have a fall of about 2 ft and have an initial velocity of zero, the final velocity can be calculated using the equation:

$$v^2 = v_0^2 + 2a(x - x_o)$$

The resultant velocity of the droplets as they impact the water is roughly 128.8 ft/s. A water droplet is also approximately .06 g, or 0.0001322 lbs. A droplet of this mass traveling at this speed impacts the pool of water with a kinetic energy of 0.046 Joules. This fairly high-speed impact sends water flying, allowing the viewer to identify freely moving airborne water droplets in fashions that are similar with those of high Reynolds numbers. Calculating the Reynolds numbers of those droplets flying out of the pool would be quite difficult since I cannot accurately estimate their velocity.

III. Visualization Technique

How I captured my image was different than the rest of my team members. I decided to utilize my camera's high speed burst ability to capture the perfect moment when the two droplets collide, whereas my teammates simply used a single long-exposure lit by a powerful flash in a dark room. In order to do my method, my camera needed a LOT of light in order to capture images at such a high speed.

Two powerful construction lights were turned on, one 250 W and one 500 W, along with the normal lights in the room. Due to so much light being present, the LEDs on the apparatus really didn't contribute much light at all. With the amount of light present in the room, the camera was able to do full-resolution burts at 40 frames per second at high shutter speeds. Along with the lighting, a simple black sheet was placed behind the pool of water in order to ensure a constant, non-distracting background.

IV. Photographic Technique

Unlike most of my other images, this one was not taken with a DSLR; it was taken with a Casio Exilim ZR-100 point and shoot camera. The Casio is quite an impressive little camera, with features that aren't in most others, such as high-speed video, great macro photography, and in-camera HDR processing. The ZR-100 also has a great high-speed burst feature, as mentioned previously. This image was taken using the high-speed burst feature, which takes full resolution pictures at 10 megapixels (3648 × 2736 pixels), at 40

frames per second. This burst is an unheard of feature on most cameras, especially point and shoots.

In order to freeze such a fast motion like the impact of the water droplets, a high shutter speed was needed. Using a high shutter speed requires a lot of lighting, which is why lighting was so prevalent on the apparatus with the construction lights. Using the high-speed burst and a shutter speed of $^{1}/_{1250}$ sec, the motion was captured with sufficient sharpness and clarity. The aperture was f/3.9 in order to maximize the amount of light reaching the sensor, the focal length was 6.6 mm and the ISO was set at 800. An incredibly difficult part of capturing the collision was getting the focus correct, in order to do this, we placed a finger on the part of the water where the droplets impact, and kept the focus on that point.

Post-processing was significant on this image as well. Using Photoshop CS5, the levels, curves, contrast, brightness, and colors were adjusted. The color of the water was made bluer to give the photo a new feel, and also the background was manually edited to be completely black to remove any distracting elements. Before and after images can be seen below in Figure 3.

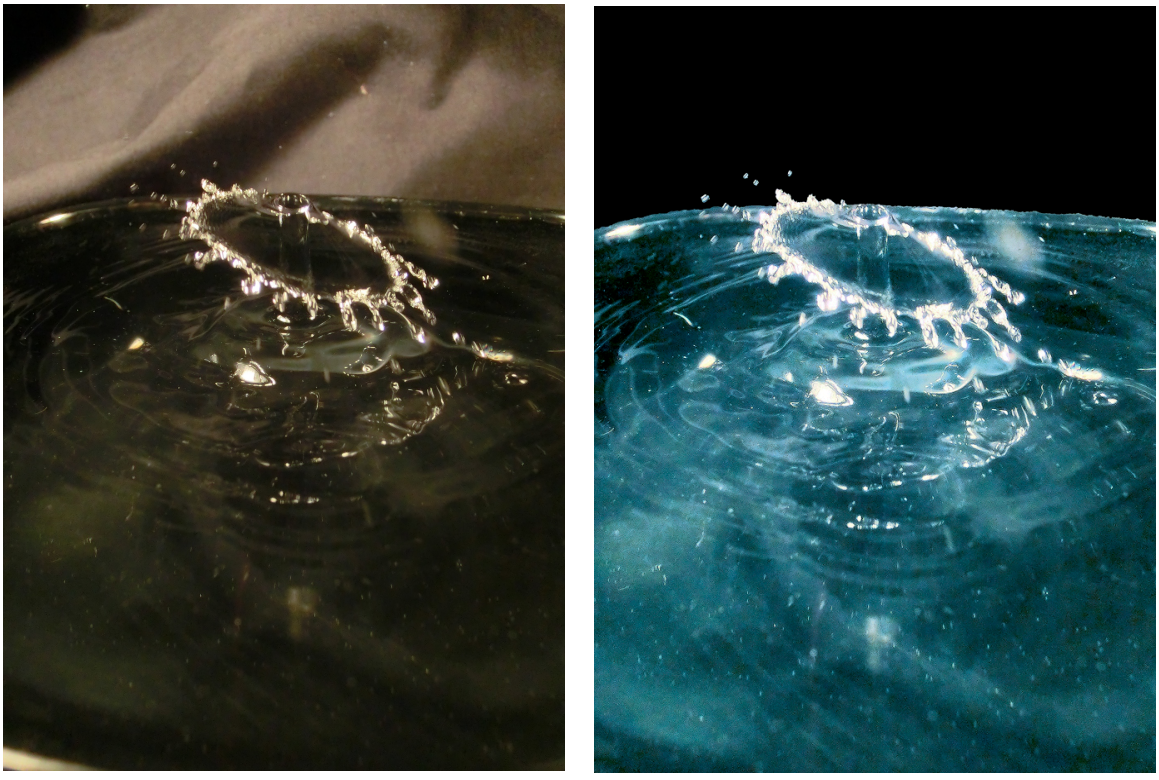


Figure 3 – Post Processing before (left) and after (right)

V. Conclusion

In the end, I am mostly pleased with the final picture. The high-speed burst mode allowed me to capture many images of the collision, however it was very hard to use and to focus. I feel as though I successfully captured the phenomenon of the Worthington jet and the droplet collision. My goal was accomplished, however it wouldn't have happened without the help of Wayne Russell for creating the droplet apparatus.

However, if I could do it again, I would use my Nikon D90 DSLR to improve the quality and size of the image. I would also not use a high-speed burst mode, I would use the method that the rest of my teammates used, a single long exposure in a dark room with a quick burst of flash at the collision point in order to illuminate the image. A manual focus lens on a DSLR would make focusing the image incredibly easy, and would allow me to take the image in a RAW format. However, I still accomplished my goals with this image and am content with it.