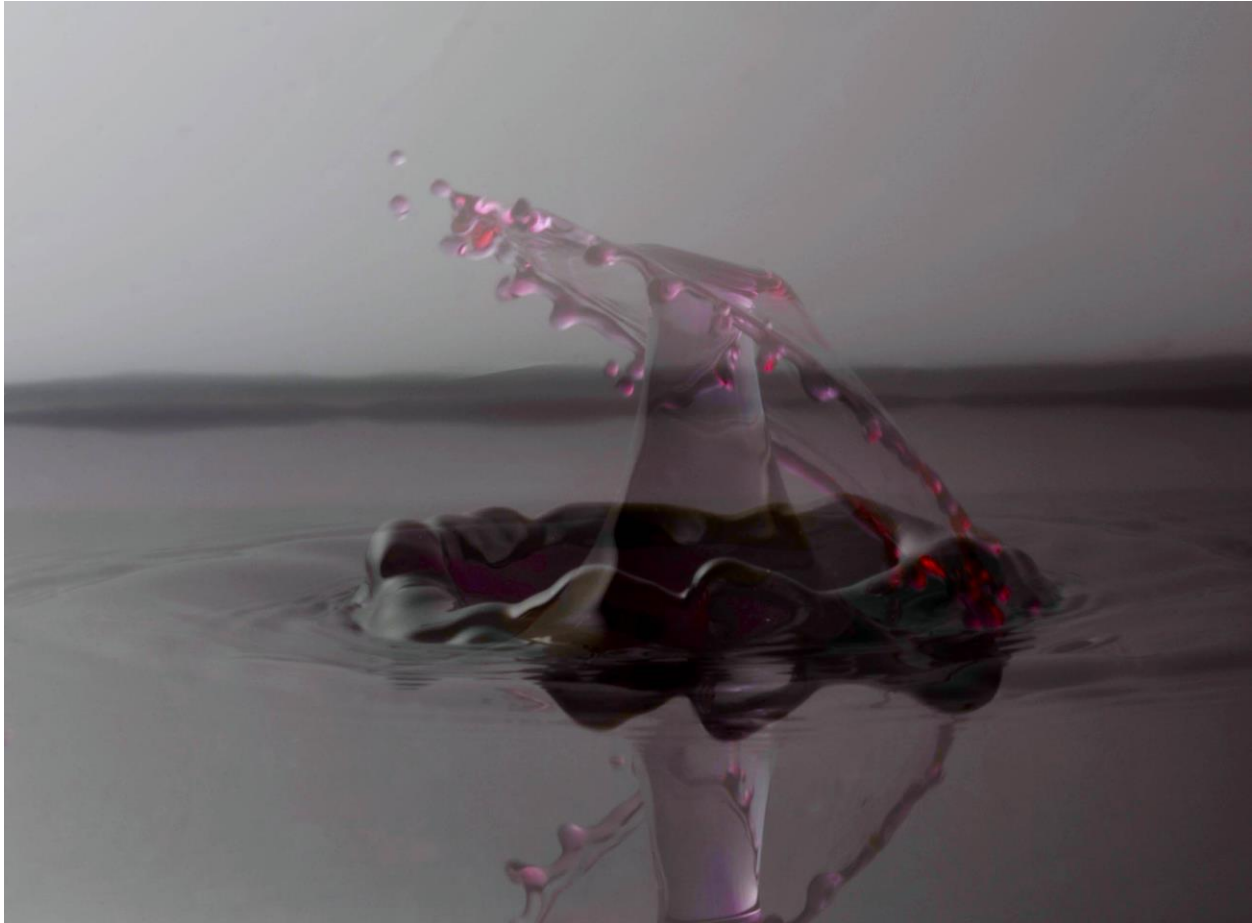


Team Third – 2016 Report



*Figure 1: Final Image*

### **Image Context**

For the image shown in Figure 1, the team consisting of myself, Joey Hall, and Schuyler Vandersluis were using a contraption created by Kyle Hollis and Kyle Walters called DropSplash for controlling the size and release rate of drops to create Worthington Jets (Hollis & Walters, 2016). We were experimenting with the setup using red and purple dyed water with various drop sizes and release timing to capture the drops in different stages of the Worthington Jet. We also aimed the two drops at each other to try and get a collision which was harder than we thought, but we did get a couple good collisions.

### **Flow Apparatus**

As mentioned prior, the flow apparatus was built by Kyle Hollis and Kyle Walters. The setup is shown in Figure 2. The apparatus contained two reservoirs for a fluid (attached to the top crossbar) with tubing connecting the reservoirs to a solenoid valve each (middle crossbar) which controlled the drops via a user interface. The user would use an app built for this contraption to input drop size and release timing. When the program was run, the drops would release and the camera would



*Figure 2: Experimental Setup*

automatically fire to capture the shot. The drops were dropped into a baking sheet filled with water below and the backdrop was a piece of white, opaque acrylic.

The image in Figure 1 features several fluid phenomenon that can be described, especially since this image exhibits ghosting from a double exposure. The first phenomenon is the crown splash present around the base of Worthington jet. The crown splash is from the first droplet hitting the water surface and creating a crater, displacing the water that was originally in the basin upwards in a circle around the drop. This was the first step present in the development of the next phenomenon, the Worthington jet. The Worthington Jet is created when the cavity left behind by the drop impact closes back in on the empty space. As the fluid closes in on the cavity, the momentum and pressure difference between the fluid and air above the cavity pushes the water up in a jet at the location of the drop's impact (Gekle & Gordillo, 2009). The next, most obvious feature of the image is the umbrella shaped circle emanating from the top of the jet.

The umbrella is created by the impact of a second drop with the tip of the Worthington Jet. This impact was slightly off centered leading to the slanted umbrella. Coming off the rim of the umbrella are small drops as a result of the Plateau-Rayleigh instability where surface tension is too weak to hold the liquid together in a sheet so it tears into fingers that break off in drops. Also evident on the back rim of the umbrella are a few ripples that are the result of the impact that just took place between the two opposing liquids (Sharp, 2013). The energy from the impact echos through the umbrella as the liquid is forced horizontal radially outward from the impact site.

## **Visualization Technique**

While the use of food coloring was not necessary, we used colored water in order to give increased contrast and vibrancy to the image. The Worthington Jet was from a purple drop of water which we found dilutes to the point that it is hardly distinguishable with color. The drop that was released second contained red dye which is evident in the increased red saturation of the “umbrella” created by the impact. The lighting was the largest reason the image appears as it does—we used both ambient lighting and two flashes. The room was lit from above by fluorescent lights to the brightness seen in Figure 2. There was also a flash to the right of the image with a red filter that can be seen in Figure 2 and a white flash behind the acrylic backdrop. The ghosting seen in the image could be a result of either the ambient light and the flashes creating a double exposed image or the two flashes firing at slightly different times to create two resolved images in one. Either way, the double exposure is interesting because it allows two phases of the drop progression to be viewed in one image.

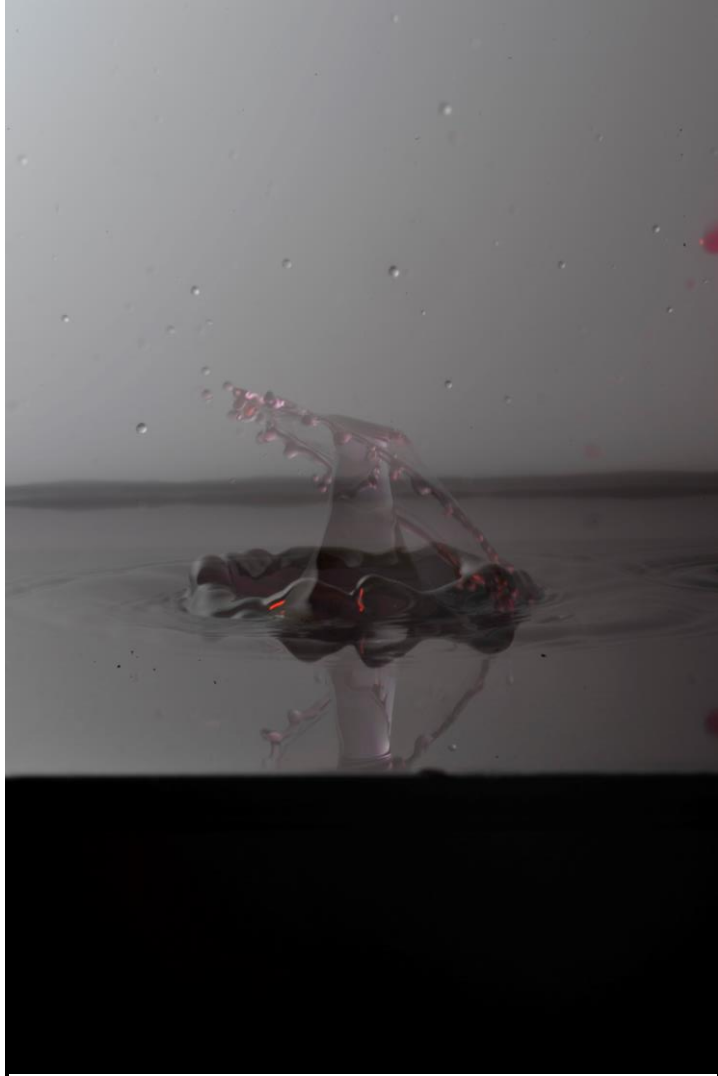


Figure 4: Original Image

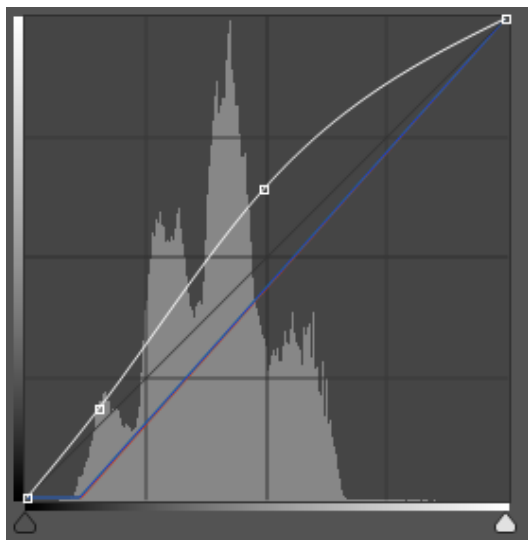


Figure 3: Photoshop Curves

## Photographic Technique

The original image is seen in Figure 3 which was taken on a Nikon D700 DSLR with a macro lens. The camera was hooked up to the controller box for the DropSplash system and automatically controlled by the program. Due to the setup with the automatic timing and delay within the system, it was required to use a  $\frac{1}{2}$  second exposure setting on the camera. The actual exposure time is not known, but decreasing it to a  $\frac{1}{4}$  second would create black image because the shutter would never actually open from the programs controls. The idea behind this is that if the experiment were to be done in a dark room, the flashes would create a well resolved image so the shutter speed wouldn't matter. The camera was also set at an ISO of 200 and aperture of f/32 so that when the flashes went off the image would not be overexposed. The focal length was 105mm with the center of focus approximately one foot from the image over a field of view of three inches across. The original image was 2832x4256 pixels but cropped down to 2515x1864 pixels along with

editing in Adobe Photoshop. The first step in processing the image was to remove distracting elements. The clone stamp tool was used to remove the smudges/droplets present on the acrylic background, the black specs in the lower left corner, as well as the two red streaks present on the clown from the red flash. These streaks were distracting elements and not important for the image so they were removed. Next, the color curves were adjusted according to Figure 4 by first setting the black point and then adjusting to increase the contrast without over exposing any of the image. Lastly, the saturation was increased to 100% to make the red in the image more apparent. This processing resulted in the final image seen in Figure 1.

## **Conclusion**

This image reveals several interesting phenomena from the impact of two droplets. The image could have had better control of light to make it better resolved and eliminate the ghosting, but working with what is available it does show a unique perspective. Since this experiment was based on trial and error to get a good shot, the intent was realized in this photo showing an awesome combination of features, but it could be improved through repeated trials at these settings with more minor tweaks and better light control as mentioned prior.

## **References**

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