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ATLS 4251: Flow Visualization
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Get Wet Report

Figure 1: Final digital image - *Water Buffalo* by Jason Fontillas, Digital Photography (2019)

For the first individual project of Flow Visualization, students were given the task to “get our feet wet” and “make a picture or video of fluids (air or water, gas and/or liquid, any fluid, any combination of fluids) that both (1) demonstrates the phenomenon being observed and (2) is a good picture,” (Prof. Jean Hertzberg). So, I made an image of black waterproof India ink squirted out of a syringe while submerged underwater. The camera used to capture the photograph was a Nikon D7500 with a AF-S DX NIKKOR 16-80mm f/2.8-4E ED VR Lens. I like this image because the ink is displayed in 3-dimensional space, which gives the subject a sense of movement and depth. The photograph depicts the Rayleigh-Taylor Instability (RTI) that describes the movement of two fluids with different densities (Jacobsmeyer).

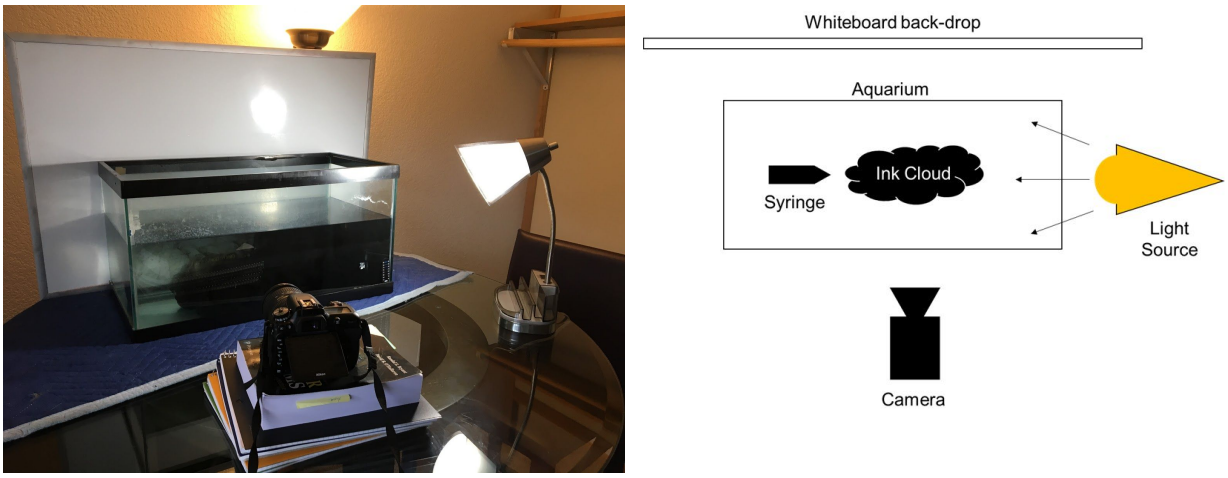

Figure 2: Photo and Diagram of Camera Setup

The figure above depicts the apparatus that I used to obtain my image. I used a 30x10x10 inch aquarium filled halfway with water. I filled a small syringe with about 2mL of the black ink and held is at the bottom of the aquarium on the left side. I placed my desk lamp with an LED light bulb on the right side of the tank to illuminate the ink at 90° angle relative to the direction that the camera pointed. The ink flow captured in the final photograph is about 5.5 inches in length by using the tip of the syringe for scale (which was cropped out in the final image) and was taken very shortly after I began to press on the syringe. The ink cloud is moving towards the right due to the force of push exerted by the end of the syringe.

The materials used in the project are shown to the right. I used Black Cat brand black waterproof India ink that is traditionally used for pen and ink calligraphy. The syringe is from the art store that has a cuttible tip to change the size of the exit hole (I did not modify the syringe tip in my project and used the smallest hole possible: 2mm diameter). I worked in a dark environment except for my single light source which was my desk lamp with a white LED light bulb. Further explanation in paragraph 1. Further analysis of the RTI being expressed in the flow can be calculated by analyzing the sequence of images and calculating the Reynolds Number (Engineering ToolBox). The Reynolds Number I calculated indicates that the flow is between a transitional and turbulent flow. In the image, large vortices are visible in the ink cloud.

t = time between 8 pictures shot at 1/80sec = 0.1 sec
d = distance travelled after 8 pictures = 1.25 inches = 0.03175 m
V = d/t = 0.3175 m/s
L = diameter of the ink in photograph = ~2 inches = 0.05 m
u = dynamic viscosity = 5.751mPa*s = 0.005751 N*s/m^2
p = density of the fluid = 1.0719 g/cm^3 = 1071.9 kg/m^3

$$Re = \frac{pVL}{u} = \frac{(1071.9\ kg/m^3)(0.3175 m/s)(0.05 m)}{0.005751\ Ns/\ m^2} = 2959$$

To capture a still image of the ink moving to the right through the water, I positioned the camera so that the lens was completely against the glass to capture the space on the right side of the aquarium where the ink would be expelled. When taking the picture, I used my left hand to squirt the ink out of the syringe and my right hand to trigger the camera. The distance from the front of the lense to the ink cloud was between 5-7 inches. The light was positioned directly to the right so that I would be able to see the 3 dimensional curves within the cloud. Working with black ink allowed me to see fine contrasting detail in the ink. I used a Nikon D7500 with with the following settings: Aperture Priority mode, f/7.1, 1/80sec, ISO 500, focal length: 28mm. The lens was an AF-S DX NIKKOR 16-80mm f/2.8-4E ED VR Lens. Below is the raw image straight from the camera (left) and the final version after processing in Adobe Lightroom and Photoshop (right). I used Lightroom mainly to edit the shadows and exposure of the ink in the curves editor. Then opened the edited image in Photoshop to crop the subject in the center of the frame, remove and noticeable smudges/marks on the glass, and remove the lower half of the background and replace it with a black/white color gradient. I did this in order to make the subject of the photo pop out on a plain background.

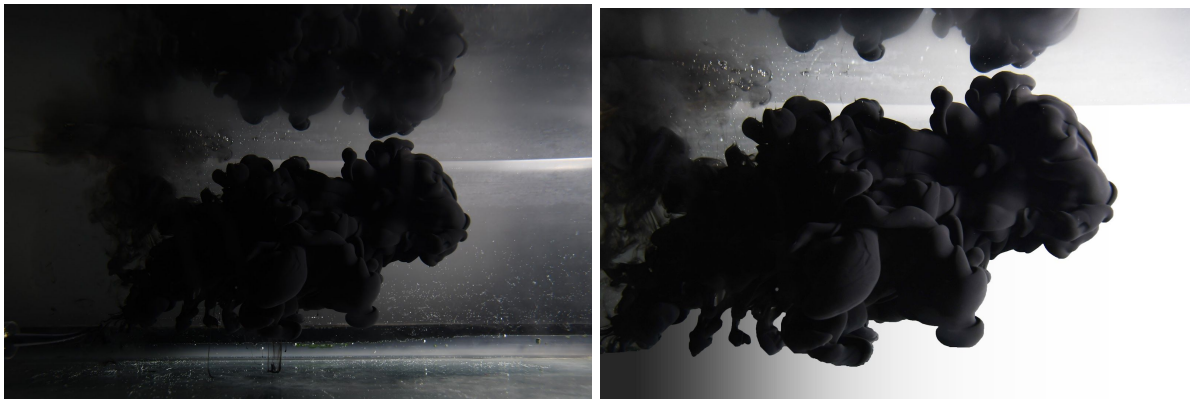

Figure 3: Before and after photographs of the ink cloud.

The ink cloud in the image reveals how a liquid flows when a force acts on a substance moving through an environment of differing density before the particles are completely diluted with each other. The round bumps making up the cloud resemble vortices in the ink as the body moves to the right which depicts the turbulent motion of the ink particles. This reflects the calculations for the Reynolds Number which is a part of the Rayleigh-Taylor Instability. Fortunately, the shape of the cloud somewhat resembles a buffalo, which gives the image an artistic look. The color gradient in the background of the image gives a sense of direction in the subject along with a clean and appealing beauty of the ink. I am very pleased with how the ink looks in the light. I would want to try using multiple ink colors colliding with each other in future projects similar to this one.

References:

Jacobsmeyer, Brian. "Mixing Physics: RayleighTaylor Instabilities." Physics Central. American Physical Society, n.d. Web. 19 Sept. 2019.

Sharp, D.H. “Overview of Rayleigh-Taylor Instability,” University of North Texas Libraries. UNT Libraries Government Documents Department. January 1, 1983; New Mexico. Web. 1 Oct. 2019).

Engineering ToolBox, (2003). *Reynolds Number*. [online] Available at: https://www.engineeringtoolbox.com/reynolds-number-d_237.html [Accessed 1 Oct 2019].