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ATLS 4251: Flow Visualization
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Team 1: Team First Report

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

For the first team project of Flow Visualization, students were given the task to work together and create an image or video of fluid mechanics. My team (Team 1) consisted of: Antonio Gueretta, Salah Ammar, Abdullah Alsaffar, Abduljalil Almasham. In the planning stages for our project, we originally wanted to work with a Rubens Tube and capture an image of flames. But, the tube was already in use by a different team, so we decided to recreate the ink-in-water experiment that I conducted for the last *Get Wet* project. Since we were working in teams, we decided that we can change the project by adding in multiple colors since we have multiple people to help squirt ink at the same time to get more interesting compositions. We usually had two people squirting the ink while the other three photographed the image. In general, we all helped refill and clean the aquarium after every take. 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). NOTE: Since this experiment was an extension of my Get Wet Report, many sections may be similar in this Team First Report.

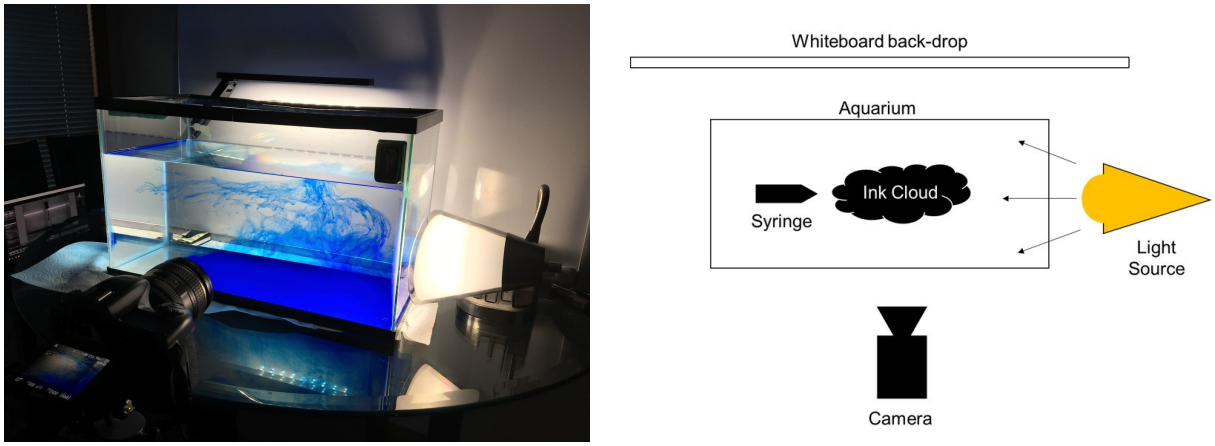

Figure 2: Photo and Diagram of Camera Setup

The figure above depicts the apparatus that we used to obtain my image. We used a 24x12x12 inch aquarium provided by Prof. Hertzberg. We 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. We used four colors of waterproof India ink: black, yellow, blue, and red. These inks are traditionally used for pen and ink calligraphy. We also had four syringes from the art store that has a cuttible tip to change the size of the exit hole (We did not modify the syringe tip in my project and used the smallest hole possible: 2mm diameter). We worked in a dark environment except for my single light source which was my desk lamp with a white LED light bulb and a second lamp to illuminate the background. 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 flow. In the image, large vortices are visible in the ink cloud.

t = time between 5 pictures shot at 1/500sec = 0.01 sec
d = distance travelled after 5 pictures = 5 inches = 0.127 m
V = d/t = 12.7 m/s
L = diameter of the ink in photograph = 0.001 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

$$Re = \frac{pVL}{u} = \frac{(1071.9\ kg/m^3)(12.7 m/s)(0.001 m)}{0.005751\ Ns/\ m^2} = 2367.0892$$

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, we added in a little bit of blue ink to test out what the colors look like in the tank. We let the blue ink disperse throughout the tank and form a background color and then added a second color. Image I captured was the very beginning of the yellow ink coming out of the syringe when the flow was only about 1.5 inches long from the tip of the syringe. The light was positioned directly to the right so that I would be able to see the 3 dimensional curves within the cloud. I used a Nikon D7500 with with the following settings: Aperture Priority mode, f/11, 1/500sec, ISO 500, focal length: 33mm. 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. I also used the noise reduction tool to make the blue ink in the back softer/blurry to put more focus on the yellow ink. Then I 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 flip the image upside down to make the surface of the water look like a horizon and give the impression that the flow is moving up.

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

I like the contrasting colors in my image with the yellow ink standing out from the blue/white background. The round bumps making up the cloud resemble vortices in the ink as the body moves downwards 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. The yellow circle at the bottom of the picture provides a nice base for the ink cloud. Working with multiple people in my team made the process of setting up the fish tank quick and easy and allowed us to do multiple shots and try different combinations of colors.

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].

Previous Get Wet Report:
https://www.flowvis.org/wp-content/uploads/2019/10/Get-Wet-Report-1.pdf