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Team Image 3

MCEN 4151

Ink in Water

This image displays the slow movement of ink while dispersing in water. It was taken as the final image for Flow Visualization, with the intent of displaying the results of resonating waves through water and its affect through water depth. The captured image combined specific lighting techniques, as well as image post-processing. By observing the path lines of the ink streaking through the water, we can see how linear water movement propagated while the ink slowly sank towards the bottom.

As previously stated, specifc methods were used in the setting up and capturing of this image. To begin, a 30” by 15” clear fish tank was filled with water. Once the tank was full, a white background object, in this case a sheet of white polycarbonate, was placed behind the tank. This allowed for the most possible contrast between the dark object (ink) and background. After this step was completed, a contractor grade floodlight was place directly in the front of the tank. The bubbles initially covering the inside of the tank wall were then wiped away by hand to ensure a clear image. This work ended up being semi-futile, as heat from the flood lamps created bubbles on the same surface during the image capturing process. Several positions and angles of the flood lamps were experimented with until it was found that direct, water plane azimuthal light sourcing provided the best image quality, as described in Figure 1.

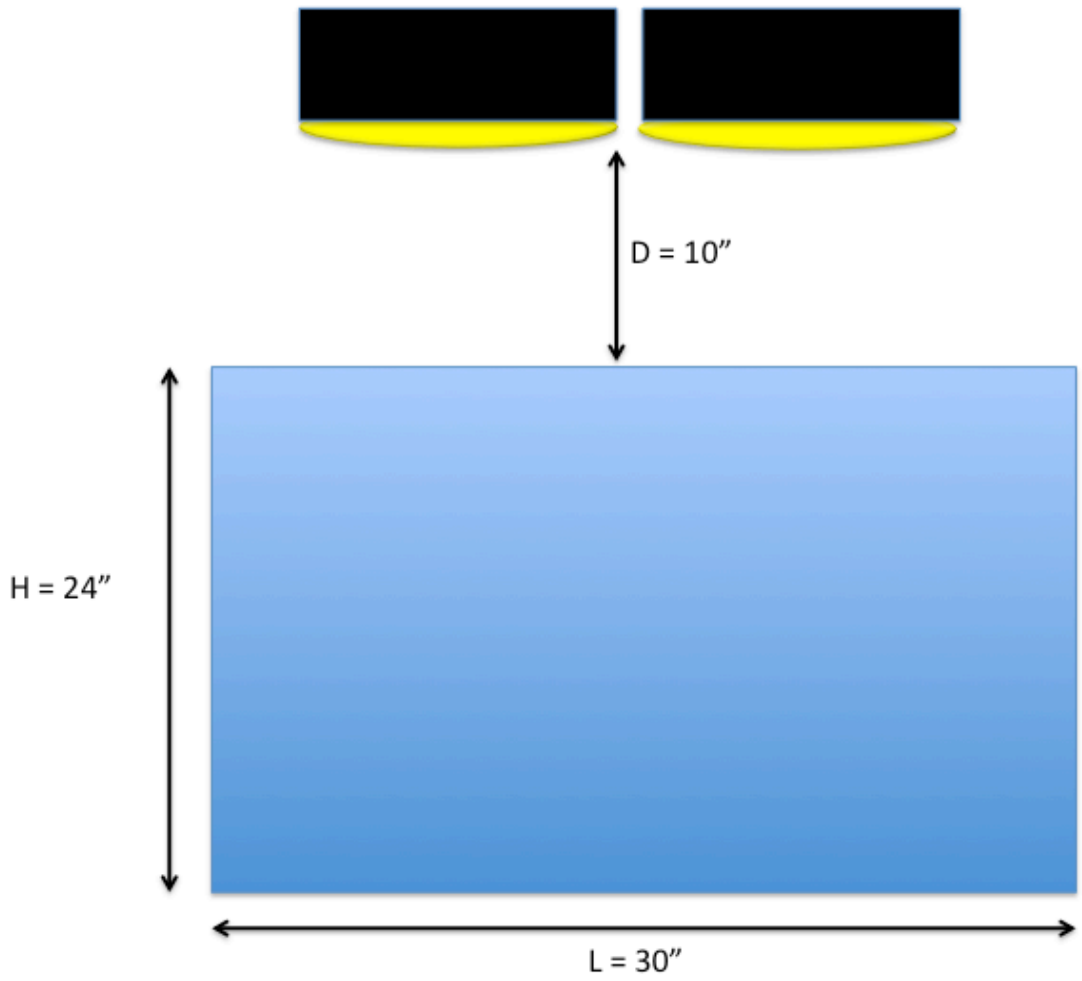

Figure 1: Physical Set Up

A pen was then cut open with scissors and the ink was squeezed out of

its container. After a few minutes of observation, the entire tank was displaced forwards and backwards quickly, to induce the linear resonance waves necessary for ink path movement.

Ink dispersion in water has been an intriguing study for many, especially those heavily vested in the ink industry. Ink has been used for many years as a method of writing, eventually evolving into the ballpoint pens we see today. The adhesion and subsequent transfer of ink from a ball to paper is crucial to a pen's success in the market, and consequently there has been research focused on ink as the main subject. One way of examining the physics of ink dispersion is by dropping a small amount of ink in a shallow container, and observing its movement pattern (*A Diffusion Model…)*. This movement is often described by the following equation:

$$D\left(\frac{\partial^2 C}{\partial r^2}+\frac{1}{r}\frac{\partial C}{\partial r}\right)=\frac{\partial C}{\partial t}$$

Where D and C is the ink diffusion coefficient in the water and ink concentration, and R is the radius of the ink droplet in polar coordinates (*Ink Diffusion in Water*). Concentration of the ink droplet is directly related to the radius of the drop and the time of diffusion. This indicates that the maximum concentration of the ink droplet will always be at the center. This was observed during image capturing, as the trail of ink originated from the middle of the ink drop, creating a teardrop shape.

As previously stated, this image was captured through the means of water and ink. The water was slightly below room temperature (~22˚ C) while the ink was at room temperature (~25˚ C). The field of view in this image is around 12”, while the distance from the ink to the lens was around 4”. A digital camera was used for this image, specifically the Sony DSC-W330 model. An ISO of 80 was used to ensure a sharp image, with a focal length of 4.7 mm. With f/2.7 and a shutter speed of 1/100, the image was able to clear and crisp. This is exemplified in the bubbles seen on the front of the glass, a result of the heat from the flood lamps. Minimal post-processing was done on this image. The temperature was “decreased” to bring out the blues more, while the range of colors were adjusted to make the background seem more white.

This image is an excellent example of two similarly dense fluids interacting extremely slowly. The water was very still before being disturbed, which may explain this slow movement. The reflection of the ink on the top also gives the image a nice feel, much like a sky raining down ink. I am curious why some of the ink dispersed along the top of the water, while some of it fell towards the bottom. This may be a result of density irregularities within the ink itself, and this would be an interesting topic to look into further. The image communicates a feeling of peace and tranquility, as the viewer can sense the slow movement of the ink as it drifts downward.

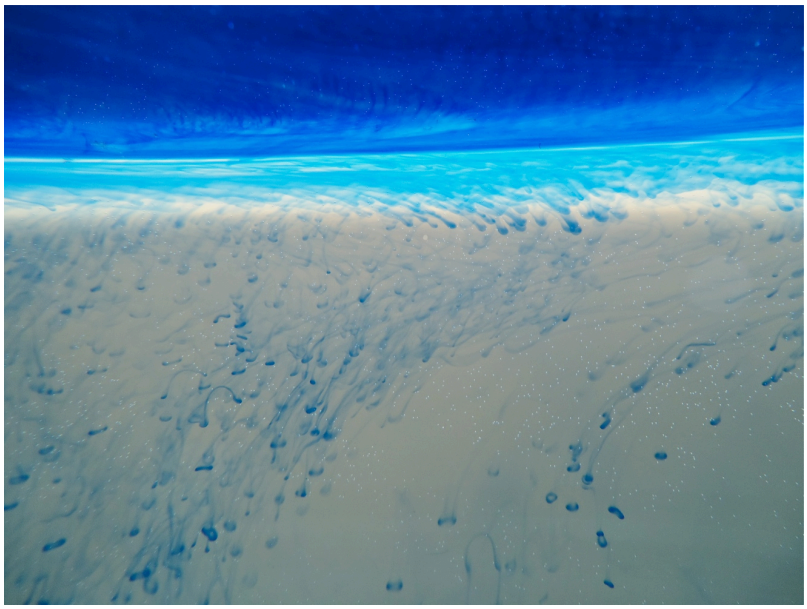

Figure 2: Edited Image

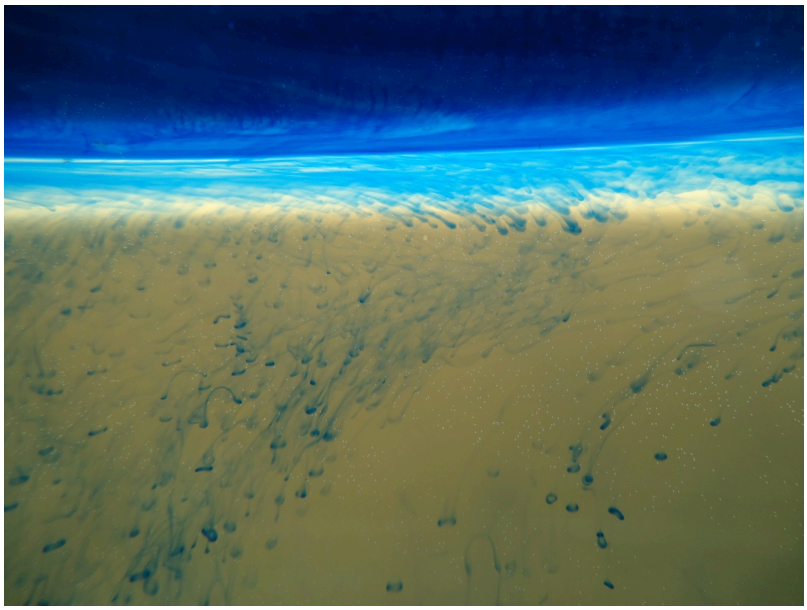

Figure 3: Original Image

References:
"Ink diffusion in water." Sanboh Lee *et al* 2004 *Eur. J. Phys.* **25** 331
"A Diffusion Model for Computer Animation of Diffusing Ink Painting." Kuni T.L. *et al* 1995 IEEE 98.