Team Image 1
Kelsey DeGeorge

Flow Visualization
MCEN 4151
University of Colorado at Boulder
Professor Jean Hertzberg

Purpose:

The purpose of the first team image was to collaborate with classmates to create a beautiful and unique image while capturing the dynamics behind fluid flow. For this image, we wanted to capture the interaction and flow of ink submerged in water. We were interested in using a black light and highlighter fluid to create a psychedelic effect in the image. I collaborated with Liam Murphy for these efforts and the edited image is shown on the title page of this report.

Image Description & Visualization Technique:

The photographic set up was very simple for this image. We placed a glass cup on top of a sheet of acrylic and placed a black light underneath the acrylic to illuminate the highlighter fluid. We then filled the glass with water and dropped different colors of highlighter fluid about 10-12 inches above the surface of the water. The test apparatus is shown in Figure 1 below. We dropped the orange highlighter in first, followed by the green fluid. The photo is rotated so that the bottom of the glass is upright for visual effect. The light source used was only the black light, as the rest of the room was pitch black. The black negative space was left in the image because it adds both a mysterious element and increases the resolution of the image, providing a higher pixel count.

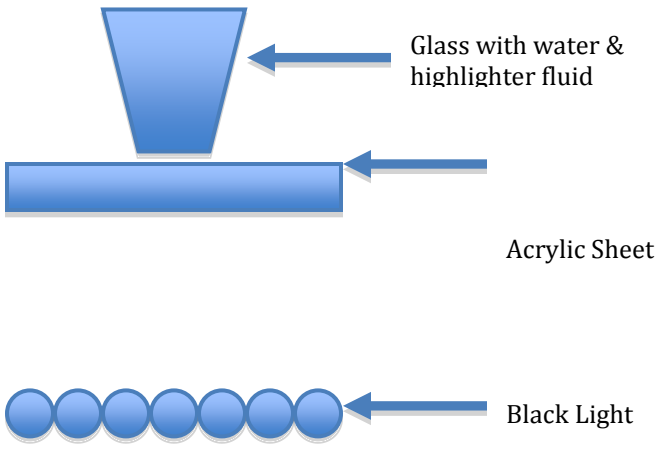

Figure 1: Experimental Apparatus

Photographic Technique:

The camera used to take this image was a Canon EOS 20D DSLR. The dimensions of both the original image and the edited image are 3504 x 2336 pixels. The focal length is 43 with an f-number of 5. I did research on what shutter speed and ISO would be best suited for taking photos with a black light, and that is why a low

aperture and fast shutter speed (1/60 s) were used. To approximate the shutter speed, I assumed the height of the highlighter fluid dropped into the water was approximately 12 inches. Using the conservation of energy from potential to kinetic and rearranging the equation to solve for velocity, the velocity of the highlighter fluid is approximated as 5.67 ft/s. In order to approximate the shutter speed, I assumed an in-focus image as an object moving $1/10^{th}$ of its size. The shutter speed is then found to be (1in/10)*(1ft/12in)*(1/8.02ft) = 0.0003 seconds. This is an order of magnitude faster than the shutter speed used, which was 1/60 seconds, but I found this speed was sufficient to capture a crisp, clean image. I needed good focus, and the high ISO (400) allowed for a large enough exposure time. I estimate that the subject was approximately 24 inches away from my camera. The editing technique used was iPhoto. I did not do a great deal of editing. I increased the saturation to get brighter colors and rotated the image 180 degrees, as well as lowered the shadows setting to lighten it. Figure 2 below shows the unedited image.

Figure 2: Unedited Image

Physics:

The physical phenomenon occurring in this image is referred to as the Raleigh-Taylor instability. This dynamic occurrence is the interaction and mixing of a less dense fluid approaching a fluid of higher density, in this case the highlighter fluid mixing with water, respectively. During this interaction, the two fluids attempt to reduce their combined overall potential energy. Initially, due to the difference in densities of the two fluids, the two do not mix and individual streams are created.

Conclusion:

I am very satisfied with the result of my image. I find that the black negative space and the florescent colors give the photo a mysterious and psychedelic vibe, which was my end goal. The formation the flow creates is similar to the motion of a jellyfish in water, which was the primary motive in the 180-degree rotation of the image. If I could repeat this experiment, I would have held my camera closer to the subject to get a higher resolution image without the negative space. Although I find the negative space adds a unique dimension to the photo, I would like to capture the detail in the flow of the highlighter fluid. Overall, I believe this image offers the viewer a mysterious, intriguing experience while capturing the flow of a unique fluid.

Works Cited:

[1] https://www.princeton.edu/~achaney/tmve/wiki100k/docs/Non-Newtonian_fluid.html
[2] http://www.scholarpedia.org/article/Rayleigh-Taylor_instability_and_mixing