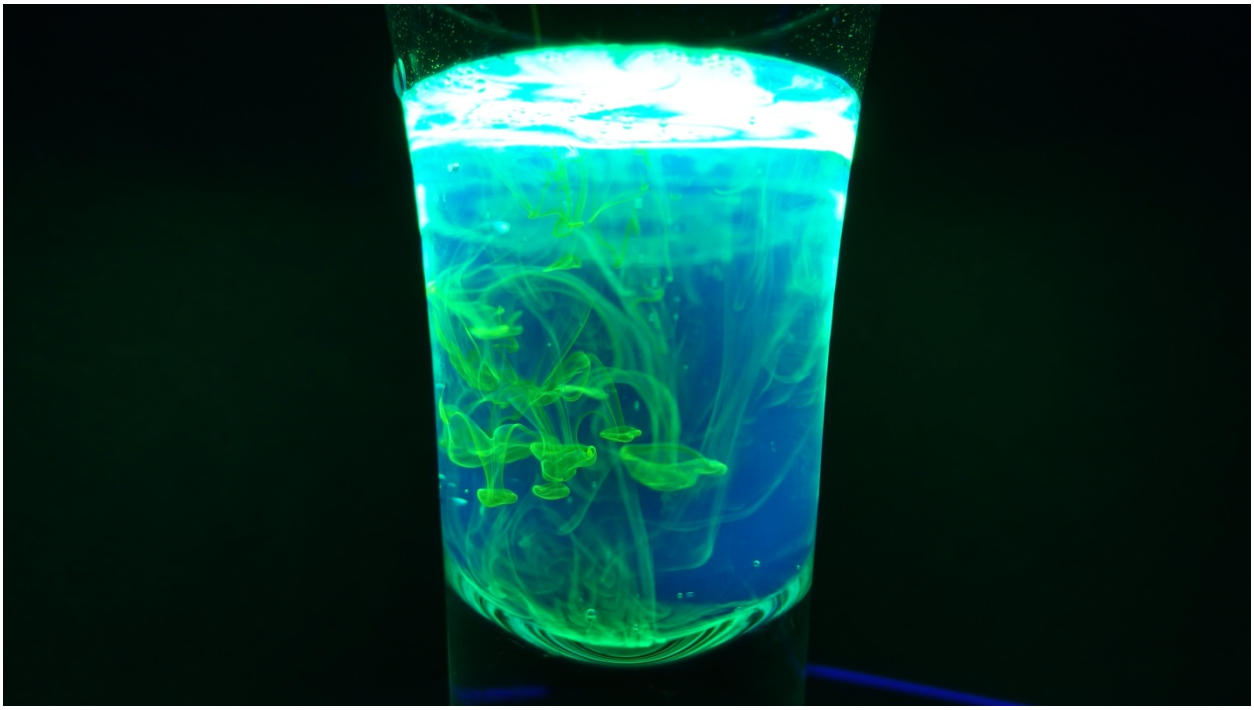
Project 6: "Team 3"
Black and Blue (and Yellow)

MCEN 5151 – Flow Visualization
Dr. Jean Hertzberg
Spring 2013



Jon Horneber
4/30/2013

1.0 Introduction

For the final project of MCEN 5151 – Flow Visualization, spring 2013, it was decided to attempt a more artistic subject of matter. The main idea behind Flow Visualization is to understand that engineering/physics behind and the aesthetics of fluid flow coincide, not impede one another. Often, this requires learning to take photographs beyond the level of automatic point-and-shoot capabilities. Initially knowing little about photography, the majority of the semester focused on taking photographs that would boost skill level in the field. As a result, the artistic perspective of fluid flow had been largely as an afterthought.

The final project focused on the artistic effects that can be achieved with ultraviolet light. A blacklight was used on tonic water, providing an electric-blue hue. Yellow highlighter was then added to the tonic water, which also was highly fluorescent. Sequential photographs were captured of the highlighter fluid's dispersal patterns, and the photographs were combined into a stop-motion video. This report will provide examples of the stop-motion photographs, and the process for creating such will be discussed.

2.0 Flow Physics

Section 3.0 discusses the photograph's detailed information, but it is prudent to discuss the flow of the apparatus, shown in Figure 1. The yellow highlighter fluid fell from approximately four inches from the surface of the tonic water in the vessel (at center). The tonic water in the container was not flat; evidence of this is seen in the video and sampled images by bubbles rising from the interior base of the container.

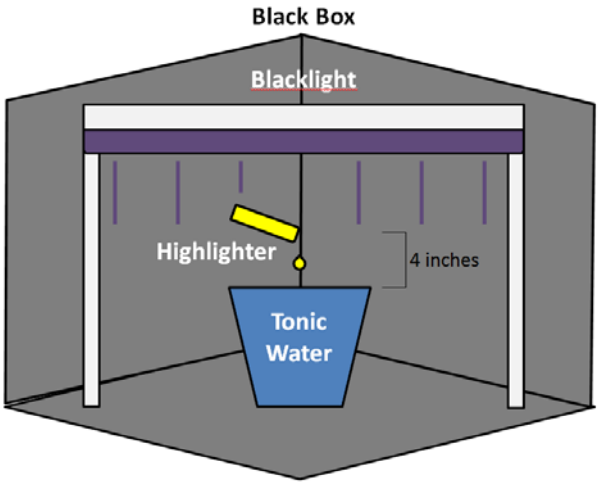


Figure 1: Flow of Apparatus

The motion of the highlighter fluid in the tonic water is due to change in Reynolds values and difference in densities. Reynolds numbers are dimensionless parameters to determine fluid flow. Low Reynolds numbers represent viscous, laminar flow[1].

[1] White, Frank. *Fluid Mechanics*. 7th. Ed. New York City: McGraw Hill, 2011. 27. Print.

3.0 Photograph Setup

The final photograph consists of yellow highlighter fluid falling through a container of less dense, non-flat tonic water. Tonic water was chosen purely for its fluorescent properties under ultraviolet light; the same is true for the yellow highlighter fluid. Following the highlighter fluid entering the tonic water, a series of pictures were taken to capture a time-lapse representation of the full motion. Once the camera's short-term memory was full, a moment was taken to save the photos and second drop of highlighter fluid was added to the tonic water/container, at which time the photo-capturing process was repeated.

Before any photographs were taken, however, a suitable photograph "black-box" was deemed necessary, also shown in the schematic in Figure 1. This consisted of three pieces of construction paper connected to form the base and two walls of a box; the walls were 7 inches tall. The photographs were focused on the corner formed by the walls. To provide lighting, a blacklight was constructed from an 18-inch closet/countertop fluorescent fixture, with the bulb level approximately 8 inches from the top of the tonic water level. No flash was used in the final photograph to prevent both blacklight washout and glare on the glass face.

4.0 Photograph Specifics

The final photograph was taken with the Olympus Stylus XZ-2 digital camera. To prevent camera shake and unintended soft-focus when holding the trigger down for sequential photo-taking, the camera was mounted on a table-top tripod. The field of view measured 6.0 x 3.0 inches; the camera lens was 4.00 inches from the tonic water container. A 1.0x zoom was used, and the focal length was 6.00 mm (28.0 mm – 35mm equivalent). The shutter speed was 1/80 sec, the aperture size was F1.8, and the ISO was set at 160. All original images were 3968x2232 (196:9 ratio) pixels and taken in .JPEG format. A sampling of original photographs is shown in Figure 2. No post-processing occurred on the originals, except for combining them into a time-lapse video. This video was the final image turned in for Project 6.

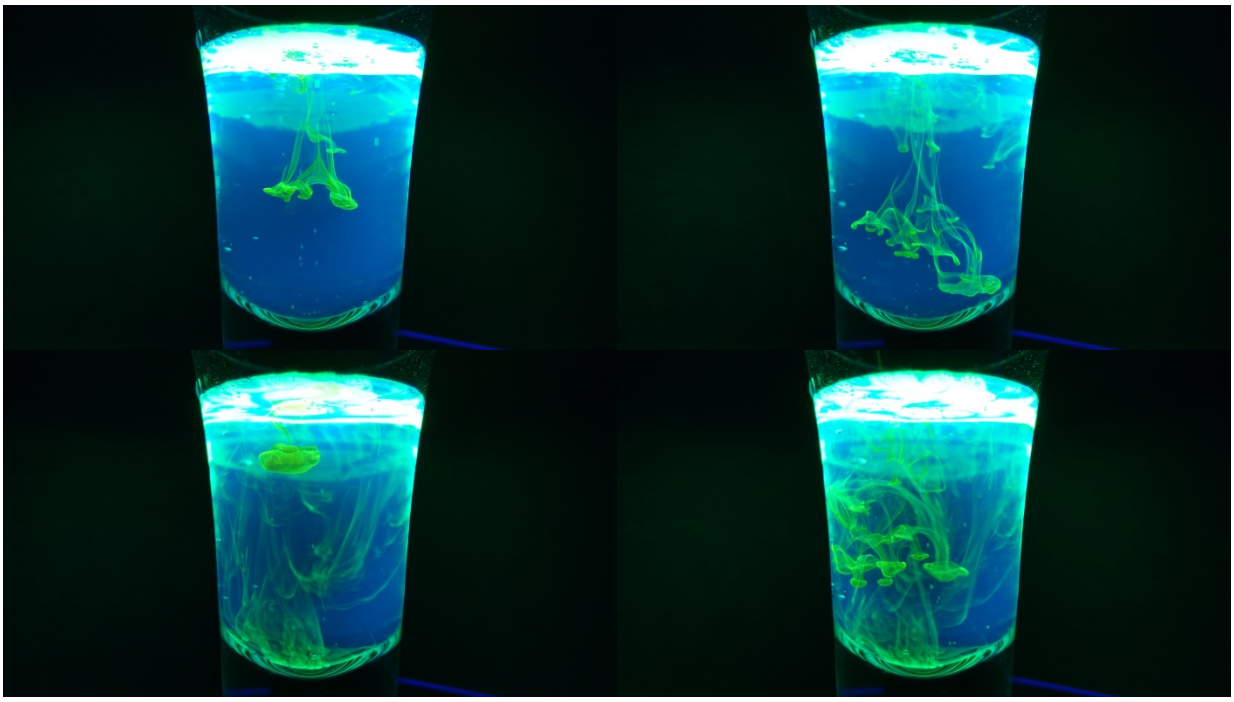


Figure 2: Sampling of Original Images

5.0 Conclusion

While not as clean as the second Clouds project, the artistic value behind the project is far greater, which was ultimately the goal for Project 6. The yellow highlighter fluid provided excellent contrast against the electric blue of the tonic water. The image was in focus, and the time-lapse video showed a really clear progression of the highlighter fluid flow patterns. However, white balance was extremely difficult to manage.

Previous work included dropping red food coloring in water. Due to a greater difference in densities, food coloring fell through water more quickly than highlighter fluid through tonic water. The tonic water also still retained carbonation; this slowed the passage of the highlighter fluid even further. However, umbrella formations were still observed. Despite the intense color under the blacklight, both the tonic water and the highlighter fluid were clear, when mixed, in regular light. This was a surprise, knowing the normal yellow color of the highlighter fluid.

Future work would be to create a more robust "black box" structure. The structure used for the photograph was not completely flush, which is evidenced in the lower-right corner of the photographs. The Scotch® tape used to hold the "black box" together was apparently slightly fluorescent, and it showed where gaps existed in the "black box". It would also be interesting to see what effects diffusing the blacklight might create. The setup had the blacklight directly overhead, which created a concentration of light at the top of the container, as shown in Figure 2.

6.0 References (Re-listed)

1) White, Frank. *Fluid Mechaniccs*. 7th. Ed. New York City: McGraw Hill, 2011. 27. Print.

2) Bosse, Thorsten, Leonhard Kleiser, and Carlos Hartel. "Numerical simulation of finite Reynolds number suspension drops settling under gravity." *Physics of Fluids*. 17.037101 (2005): 3. Web. 11 Feb. 2013. <http://me.ucsb.edu/~meiburg/pubs/Bosse_et_al_2005.pdf>.

3) Chandrasekhar, Subrahmanyan. *Hydrodynamic and Hydromagnetic Stability*. Dover Ed. Dover Publications, 1981. 428. Print.