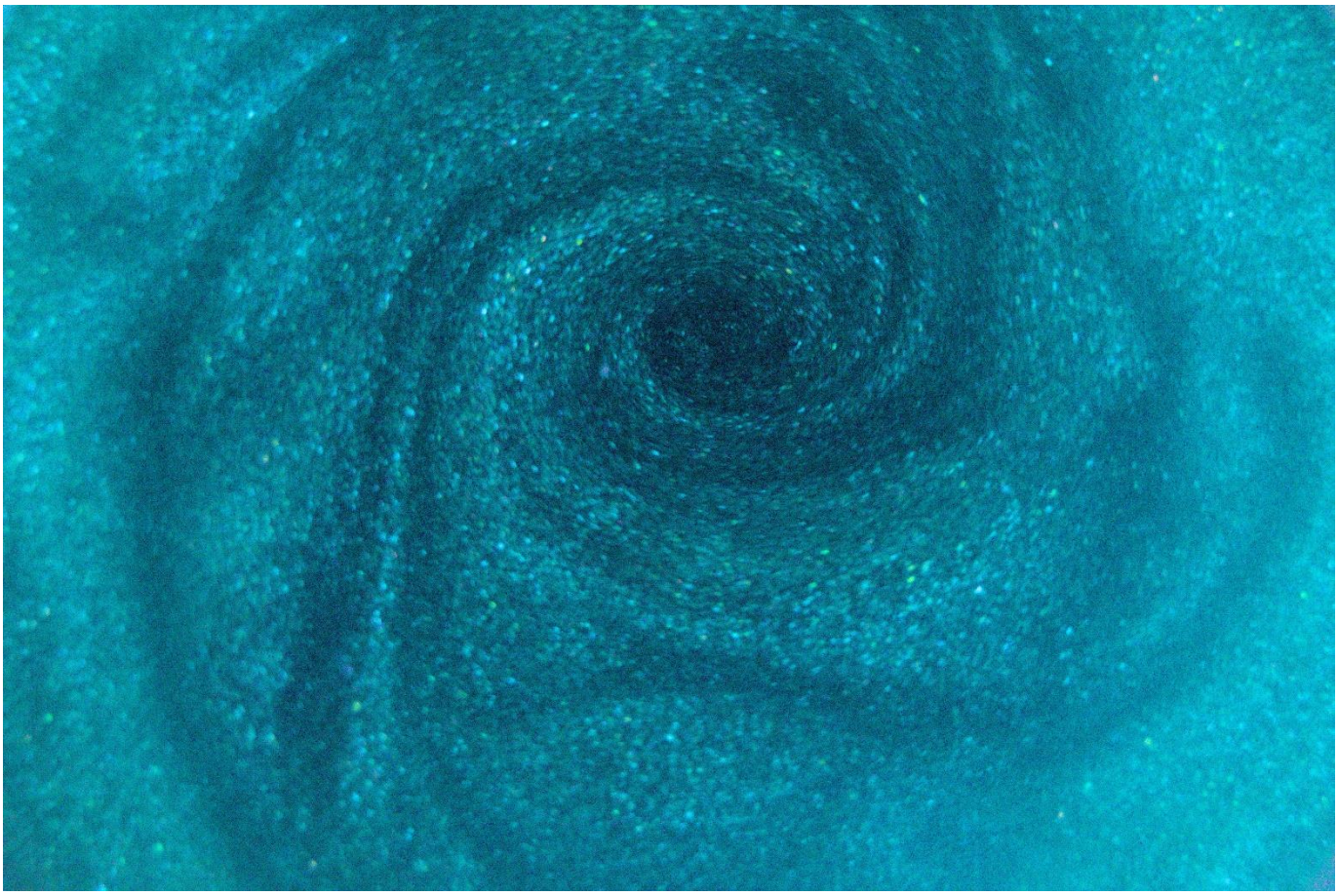

Team First Report

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Acknowledgments:

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MCEN 5151: Flow Visualization

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I. Overview

This image was taken for the second team assignment for MCEN 5151: Flow Visualization. For this assignment, my team decided to explore using a rheoscopic fluid to visualize the details and intricacies of turbulent flow. As this assignment was due just after Halloween, we decided to demonstrate flow in fun, Halloween themed cocktails comprised of a mixture of rose and blue curacao for color. For my image, I decided to display the contrast of green glitter in a dark blue background. While the color of the glitter ultimately ended up blending in with the background, I think the monochromatic coloring of the final image shows the vortex in an interesting way, with the variation in the shadows and the color value demonstrating changes in the fluid flow.

II. Experimental Set Up

For this assignment, I used a glass with a diameter of 3.5 inches and a height of 4 inches. The fluid is a mixture of water (~ 8 ounces), Underwood Rose Bubbles (~ 4 ounces), blue curacao (De Kuyper), blue food coloring (Wilton), with 3 large inches of green edible glitter (Muloen). I used a straw to swirl the image in a circular pattern. I held the straw just above the bottom of the glass so that the entirety of the fluid flowed in the same pattern. This set up is shown below in Figure 1.

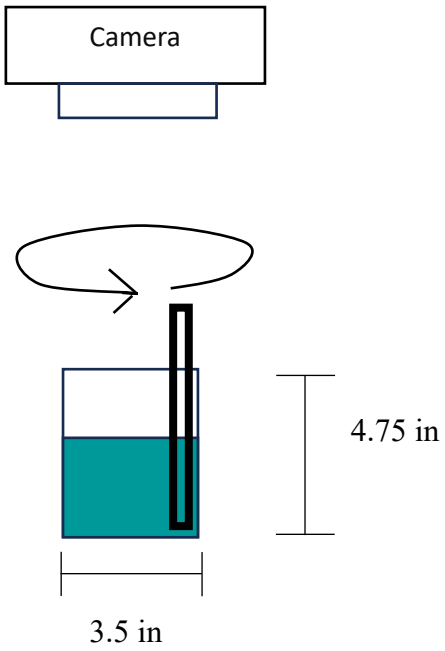

Figure 1: Experimental set up.

III. Visualization and Photographic Techniques

This photograph was taken in the ITLL during the afternoon with a combination of natural light from the windows and overhead lighting. The photograph was taken from above, with the camera about 5 inches from the surface of the fluid. The field of view of the image is about 3.5 inches.

This image was captured using a Nikon D3200 DSLR camera with a Nikon AF-P Nikkor 18-55 mm lens set to a focal length of 46 mm. To capture an instantaneous snapshot of the flow, the exposure was set to 1/160 s, the aperture to f/6.2, and the ISO to 12800. The original image has dimensions of 6016 x 4000 pixels, and the edited image has dimensions of 3000 x 1995 pixels.

When editing this image, I kept my changes relatively minimal. I cropped the image to remove the glass so that the fluid would take up the entirety of the image, increased the saturation to improve the visual interest of the image, and increased the contrast and shadows so that the vortex would stand out more. The original unedited image is shown below in Figure 2.

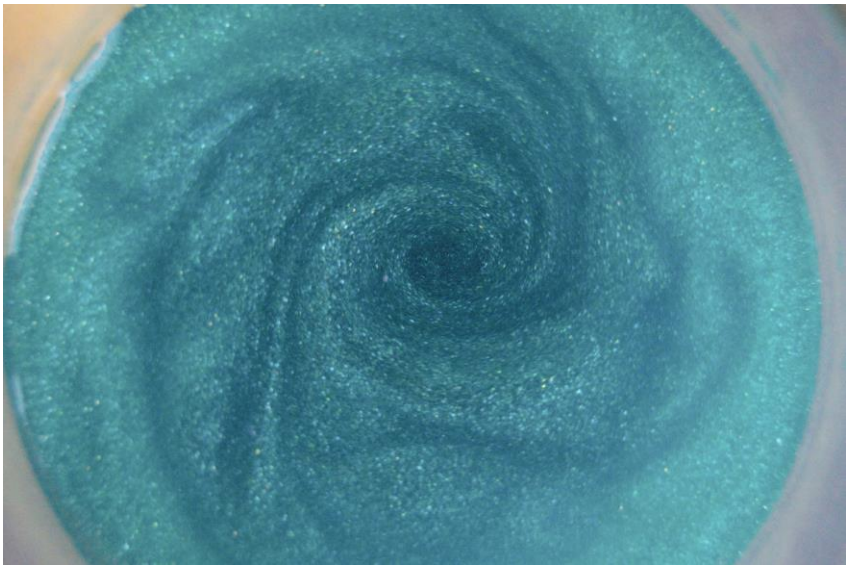

Figure 2: Original unedited image.

IV. Fluid Dynamics

a. Rheoscopic Fluid

A rheoscopic fluid is one seeded with "small, anisotropic, reflective particles" [1]. These particles become "preferentially aligned" in the flow due to their anisotropic property, which leads them to scatter light differently and highlight different sections of the flow [1].

b. Stokes Number

The Stokes number is a dimensionless number that characterizes the flow of particles suspended in a fluid. In this experiment, the glitter particles are suspended in the mixture of alcohol and water. The formula for Stokes number is shown below in equation 1, where t_p is the particle relaxation time and t_s is the characteristic time of the fluid motion.

$$St = \frac{t_p}{t_s} \tag{1}$$

Equation 2, below, is the formula for t_s. Here, L_s is the characteristic length of the fluid (the diameter of the glass), and U_b is the velocity of the fluid, calculated from a video taken during the experiment.

$$t_s = \frac{L_s}{U_b} \quad (2)$$

To estimate the particle relaxation time, I looked at a video taken after the experiment was completed where the glitter particles settled to the bottom of the glass.

Table 1: Values for Stokes number calculation.

Variable	Value	Value (SI)	Source
L_s	3.5 in	0.0889 m	Measured
U_b	1 in/[(2.45 s – 2.27 s)]	0.14097 m/s	Estimated from video
t_p	0.40 s	0.40 s	Estimated from video

Using the values from Table 1, above, I calculated a stokes number of 0.63. A Stokes number of <1 means that the particles are in velocity equilibrium with the fluid, which makes sense based on what is shown in the image [2].

V. Image Conclusions

Overall, I am happy with this image. I think that the color of the fluid and the beauty of the flow pattern combine to create an image that is very visually appealing. For future experiments, I would use a larger container in order to create a larger flow pattern. This image ended up looking slightly grainy due to the large size of the glitter particles. I think if I was able to take the image from further away with a larger field of view, the final image would have looked a lot smoother.

VI. References

[1] Borrero-Echeverry, D., Crowley, C., Riddick, T. (2018), Rheoscopic fluids in a post-Kalliroscope world. AIP Physics of Fluids. https://doi.org/10.1063/1.5045053

[2] Tu, J., Yeoh, G.H., Liu, C. (2018). Computational Fluid Dynamics: A Practical Approach. 3rd Edition. Elsevier Ltd.