MCEN 4151: Vis 1 Report

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1 Introduction

For the first project, my intent was to capture water flow using food coloring. Eventually, I settled on attempting to visualize a vortex. Whilst experimenting with the ways to do this, I determined that a drop of food coloring, dropped directly into the center of the vortex, highlights the water movement in the vortex without spilling out elsewhere into the fluid. Finally, I chose to use green dye as it gave the image a very high contrast, magical look. This project was assisted by Kelsie Kerr, who helped with lighting and camera operation.

2 Setup and Relevant Physics

The apparatus setup was fairly straightforward. A 16 oz Ball Mason jar (with something between a square and circular cross-section) was placed on a table against a wall. A white bed sheet was draped over it the table and extended up the wall behind it. This was secured in place using generic duct tape. The camera (Sony a7iii) was positioned approximately 1 foot away from the jar and placed on a tripod. The tripod was adjusted so the camera was at the same height as the jar, such that the shot would be straight on to the side of the jar (broad end facing the camera). Two IFB576 lights were placed to either side of the camera, facing the jar. These were elevated to roughly a foot above the jar/camera height and were angled down slightly. Brightness was at 100% and the color temperature was set to 5600 K (coolest setting). A picture of the setup is shown below in Figure 1.

In this photo, one of the effects we can see is the Tea Leaf effect [**1**]. This is what causes the food dye to remain only in the center of the vortex rather than dispersing. Because of the friction between the fast moving water and the boundaries of the jar, a higher pressure zone is created along the outside of the flow, resulting in a pressure gradient that forces particulates in towards the center of the vortex. Additionally, we can see the water surface appears at a lower level in the center than the outsides. This is due to the centripetal forces on the water [**2**].

Figure 1: Light and Camera Placement

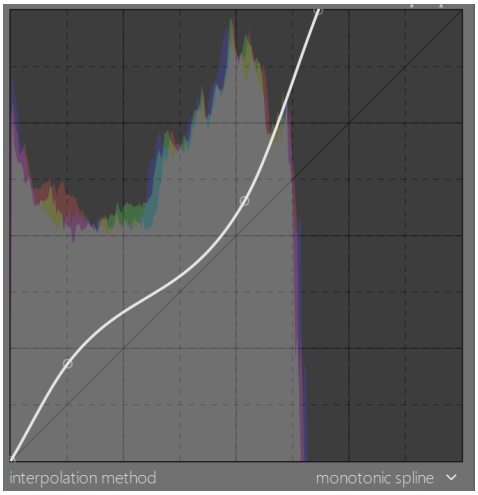


Figure 2: RGB Curve in Darktable

3 Visualization Technique

As aforementioned, food coloring was the medium used to visualize the water flow. A single drop of green HY-TOP food dye was placed as near to the center of the vortex as possible. Room temperature tap water put in the jar (filled to about half an inch from where the top curves inwards) was left for a few minutes. An IKEA milk frother then was used to create a vortex within the jar, it was held in until the vortex was no longer increasing in size. At that point, the frother was removed rapidly, straight upwards, and the drop of dye was dropped as quickly as possible.

As discussed in the setup section, the lighting was done by 2 IFB576 lights in an otherwise dark room. The brightness settings were at the maximum (100%) and the color temperature was set to the coolest setting (5600 K). The camera flash was off.

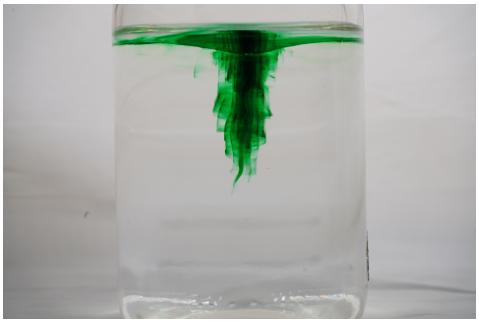
4 Photographic Technique and Choices

The field of view of the cropped image is approximately 12 cm across and slightly over 8 cm vertically. This really allowed the focus of the image to solely be on the vortex, while still giving some context of the surrounding jar. The distance from the object to the lens was approximately 0.4 m in order to get as good resolution and focus as possible. The lens focal length was 70 mm. As aforementioned, the camera model was a Sony a7iii ILCE. The lens was a FE 28-70mm F3.5-5.6 OSS. The original image had a width of 6000 pixels and a height of 4000 pixels. After cropping the photo had a width of 4757 pixels and a height of 2968 pixels. This was done to crop out blank space that seemed to take some of the focus off of the subject. The exposure specifications were as follows. The aperture was set to f/11.0, the exposure was 1/25 with a bias of -0.30 EV, and the ISO setting was 100.

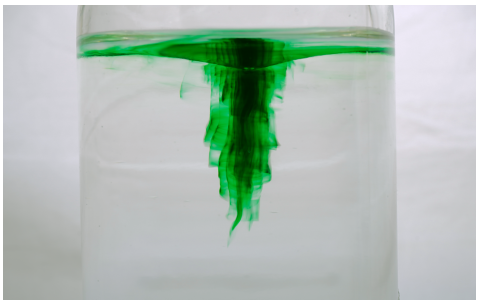
Darktable software was used for image editing. The RGB curve is shown in Figure 2. It was adjusted to accentuate the contrasts on the high and low ends of the color spectrum. The image was cropped as described above. While most of the editing was very minor, all of it acted to bring all of the focus of the image to the vortex. The image before and after can be seen in Figures 3a and 3b

5 Further Work

The image reveals the shape of the vortex of water, even in the absence of an air funnel such as one that would appear if draining a bathtub. Personally, I like the way the vortex gets almost black in the center as the density of dye and the amount of light blocked increases. It creates a sense of fantasy as to the many ways to anthropomorphize the dark, twisting figure. I'm still curious as to why we see the sort of "curtains" that form along the vortex, creating a sort of jagged edge. If I were to replicate this experiment in the future, I would like to do more takes, as I was able to deliver a more centralized



(a) Original, Unedited Image



(b) Edited Image

Figure 3: Image Before and After Edits

drop on a take I did afterwards without the camera, and I would like to take video of the phenomenon to show how the vortex progresses over the course of a minute or so.

References

[1] Tandon, Amit, and John Marshall. "Einstein's Tea Leaves and Pressure Systems in the Atmosphere." The Physics Teacher, vol. 48, no. 5, 15 Apr. 2010, pp. 292–295., https://doi.org/10.1119/1.3393055.

[2] "Water Spinner." Exploratorium, 2 Oct. 2020, https://www.exploratorium.edu/snacks/water-spinner.