IV 2 Report

MCEN 5151-001

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10/12/2020

The purpose of this photograph was to capture laminar mixing. In order to make the photo aesthetically appealing, I decided to mix the illuminous liquids in glowsticks. When starting this project, I knew I wanted to work with glowing fluids due to the trouble I had lighting my IV1 photo (smoke trail from incense). It was very difficult to set up the lighting I wanted, and I found myself thinking how much clearer I could make the image if the liquid itself was the light source. This is what inspired me to work with glow-stick fluid. Originally, I was trying to capture the beading effect of non-stick surfaces by running glowstick fluid down a mirror that had been treated with a non-stick spray. The results were not satisfactory, so I created a trough with black vinyl, poured different colored glow-stick fluid on each side of the trough, and captured the mixing in the middle. The following produced my final image, pictured below in Image 1.

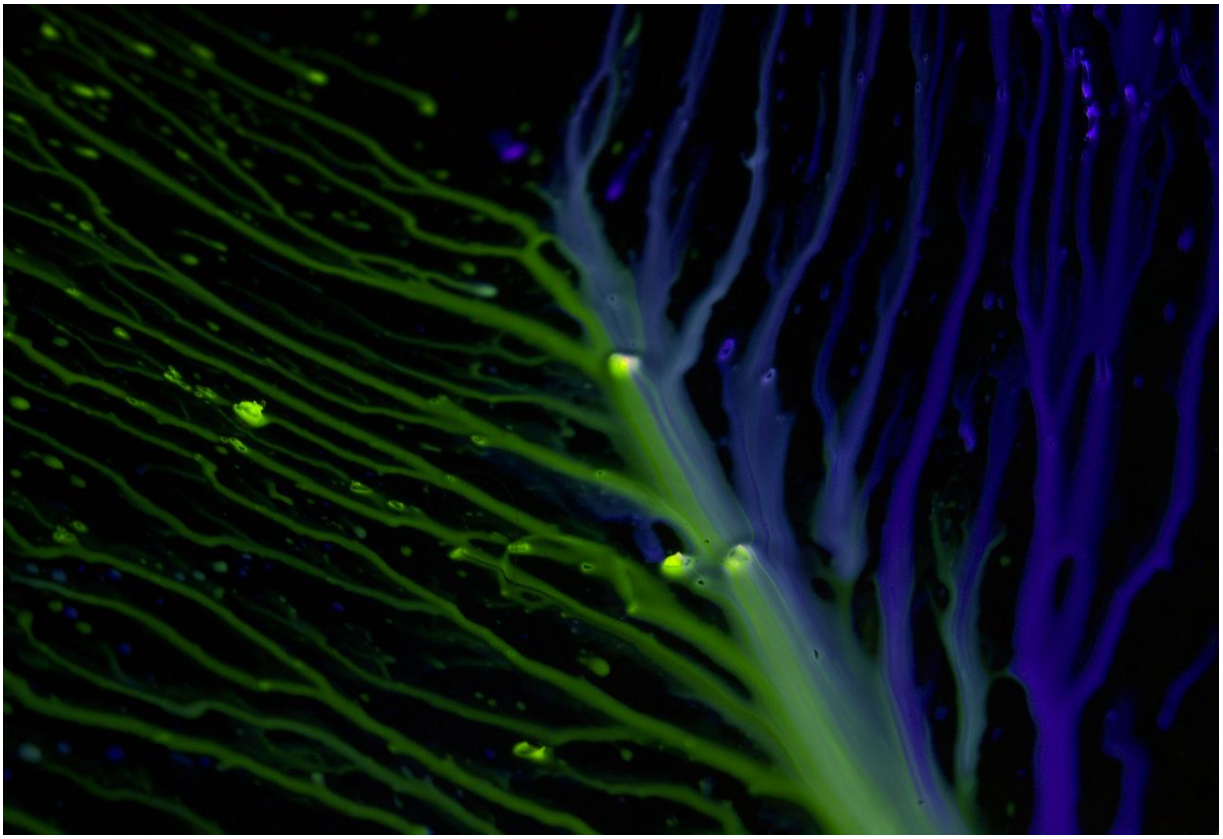

Figure 1: Final image submission

As stated previously, the flow apparatus was a trough made out of black vinyl paper by folding it into a half-pipe like configuration, as diagrammed below.

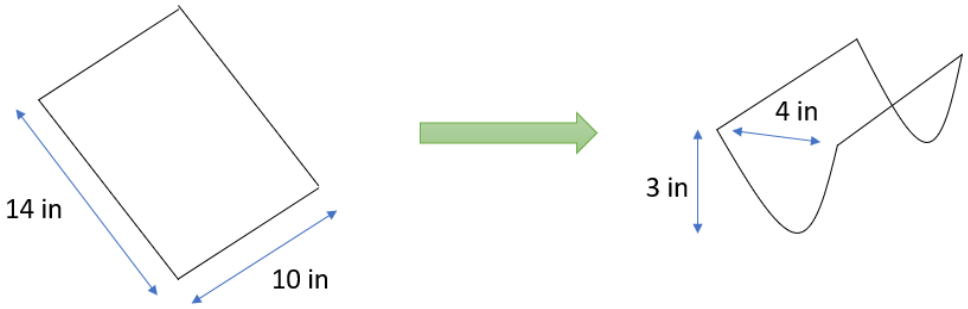

Figure 2: Schematic detailing trough creation from flat vinyl paper.

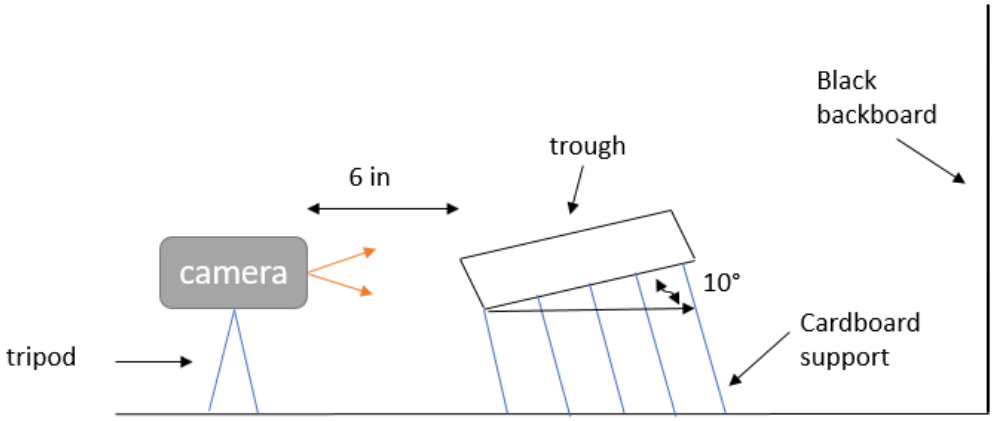

Figure 3: Schematic of picture set-up

An estimated 15 mL of fluid was poured down each side of the trough, which was set at an 15° degree angle above horizontal (see Figure 3). The resulting flow at the bottom of the trough was estimated to have a 1 cm diameter (d) and a velocity (u) of 3 cm/s. Because glowstick fluid is aqueous, we can assume the kinematic viscosity (v) of the fluid is that of water 1.004 x 10^{-6} and estimate that that Re = 300.

$$Re = \frac{ud}{v} \qquad \textit{Eq. 1}$$

With a Reynolds number of 300, we can expect the flow to be laminar. The flow pictures meandering rivulets. Rivulet meandering starts due to irregularities at the origin of the flow. While spraying the glowstick fluid onto the black vinyl, the glowstick fluid was not distributed evenly, and the vinyl paper does not have perfect surface consistency. As a result, rivulets were bound to form. The rivulets were then reinforced and amplified by the cohesive properties of the fluid- the fluid that finds the low resistance of the rivulet accelerates and pulls more fluid with it [2]. Given that the glowstick fluid was poured onto the sides of the trough, the phenomenon pictured resembles that of a flash flood. When heavy rain falls onto geography like a gulley or a valley, the runoff forms meandering streams that collect at the lowest point. This is pictured in the final image.

Laminar mixing is also displayed. This is detailed by the lines of color that are maintained in the center of the flow, even after the meandering rivulets have collided. This depicts that the laminar flow keeps its integrity, and that mixing occurs in a laminar way [2].

The glowsticks used to create the image were from D.M. Merchandising *GLOW STICKS ULTIMATE Party Pack.* Six total 8" glowsticks were emptied to create the image (three green, three purple). The glowsticks were emptied onto ORACAL 631 matte black vinyl paper. The picture was taken in complete darkness: the only significant light was from the liquid itself.

The photograph itself documents an area 6" wide by 3" tall by 10" deep. The distance between the camera and the subject, as well as other geometries, are specified in Figure 3. The camera used was a Sony α6000 and the lens used had a 35mm focal length. The Sony α6000 captures 24.3 megapixel images. The image was taken with F-stop: f/5, a 1 second exposure, and an ISO-100. The 1 second exposure did not cause motion blur, the flow appeared static when the picture was taken. The low ISO level was chosen to reduce graininess in the low light environment, and the f/5 provided the desired depth of field. The image was processed in Darktable. The largest changes were in cropping and picture rotation. The picture was rotated 29° clockwise, and about 15% of the figure was cropped. The saturation of the greens and purples were booted 40%. The original photo is pictured in Figure 4, which can be compared to the final Figure 1. The final image had a pixel size of 3125 x 2130, and the original was 6000 x 4000.

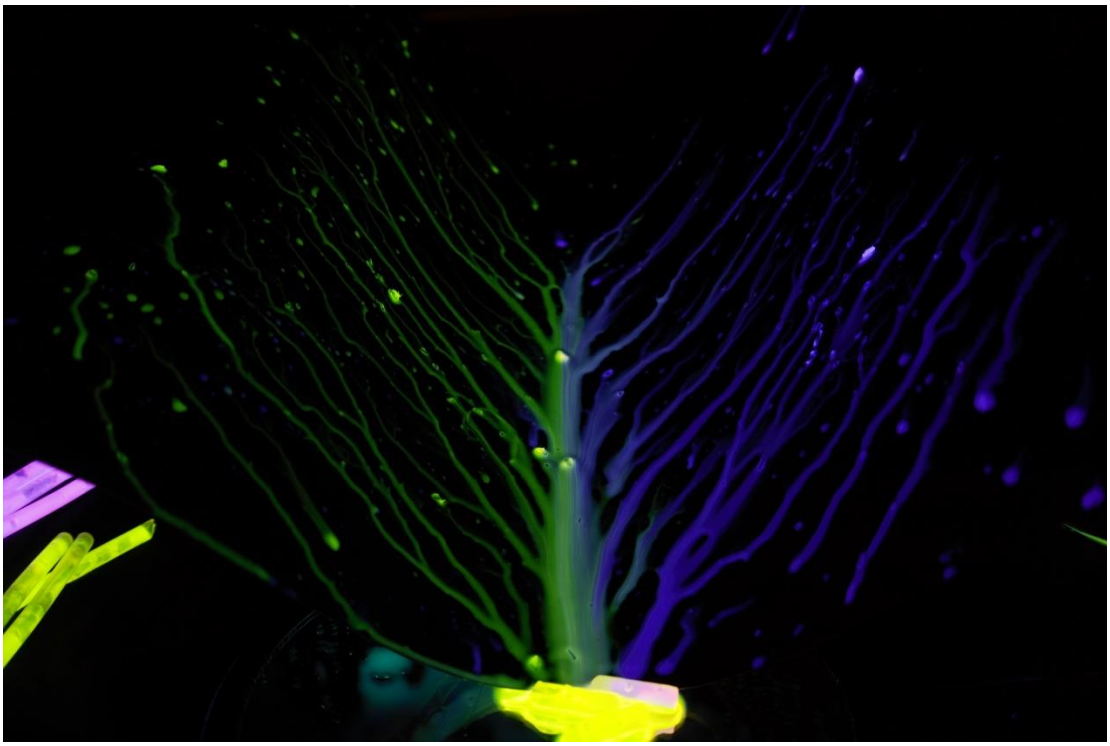

Figure 4: Original image captured.

The image reveals the behavior of colliding meandering rivulets. I enjoy the color of the image against the black background. The lines formed by laminar mixing are crisp and aesthetically appealing, and the meandering streams form not only a nice visual effect, but also a clear demonstration of the meandering stream cohesion phenomena. I want to further explore why the lines of color bend the way they do around the glass debris in the middle of the flow. I could improve the demonstration by adding one more color to each side. This could demonstrate how fluid further down the trough interacts with fluid that was poured further up the trough but on the same side. Would there still be laminar mixing? To further explore this idea, I would like to pour glowstick fluid over different geometries and see if the meandering rivulets behave in a particular way. Overall, I am pleased with the image because it is aesthetically pleasing and demonstrates fluid flow phenomena.

Work Cited

[1] Erwin, L. (1978), Theory of laminar mixing. Polym Eng Sci, 18: 1044-1048.

[2] Vorobieff, P., et al. *Meandering of a Particle-Laden Rivulet*. 2009, pp. 295–304,

doi:10.2495/MPF090251.