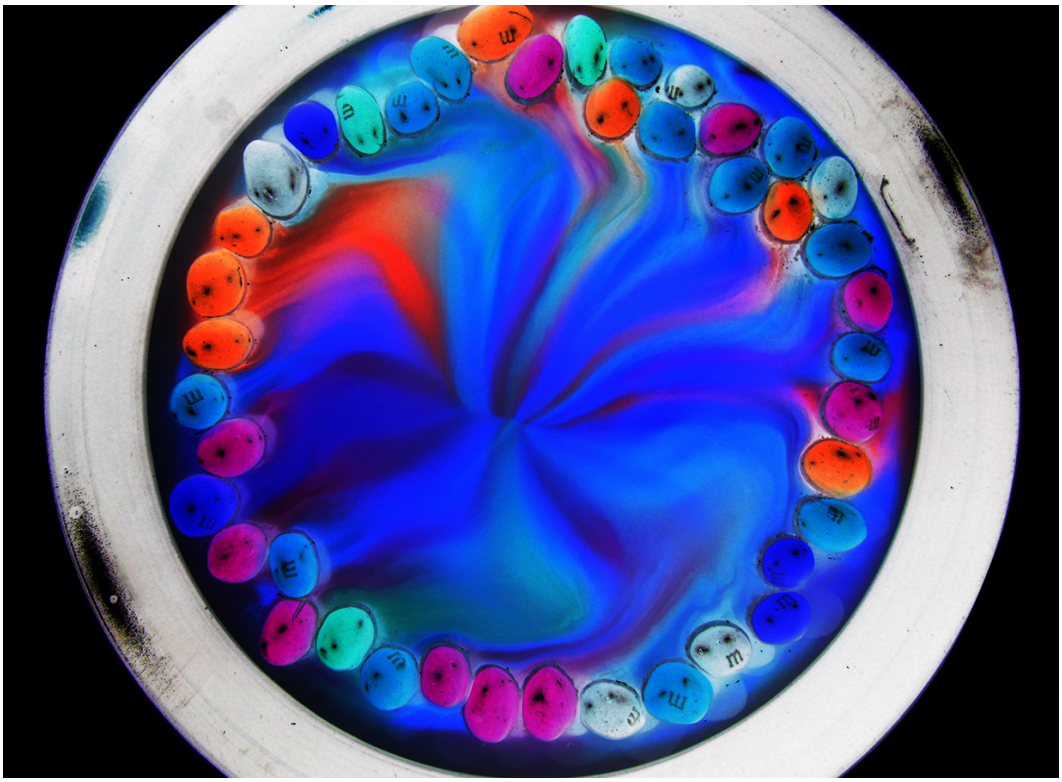
Get Wet

Fall 2019



MCEN 4151-001: Flow Visualization

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INTRODUCTION

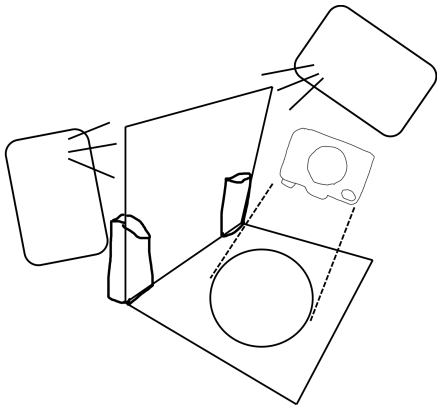
For this "get wet" assignment, we were instructed to take a picture that demonstrates a special phenomenon of any fluids, but we had to also make sure the picture itself is good both through professional photography skills and through editing using specialized softwares such as Photoshop. For my experiment, I wanted to try an interesting phenomenon that I once saw in a YouTube video, and explore it in more details. Basically, I created a ring of m&m candies in a circular plate, and then poured some water in the middle. As time went on, the water started dissolving the food coloring and sugar from the candies and gradually absorbed their color, leaving a beautiful flow resembling a rainbow as shown in Fig. 1. My friend Abdullah Alsaffar helped in setting the appropriate lighting for the image.

Figure 1. The original captured photo of the flow.

EXPERIMET SET UP

We wanted to set up a good source of light and background for the picture. To do this, we used 2 pieces of A4 paper, soda cans. and iPhone flashlights. First, I slid one of the papers under the plate that we were going to put the candies in to make a full white background for the picture. Second, Abdullah Alsaffar had an idea for the lighting, which was to use some soda cans to keep the second A4 paper standing in place, and then use the flashlight of our two phones as a light source behind that paper. Other lights in the room were all turned off. The entire set up is shown in Fig. 2.

a)



b)

Figure 2. (a) Setup sketch. (b) The actual setup, minus the plate instead of the glass.

After this, I began the actual experiment by arranging a ring of m&m on a plate. To get a sense of the picture scale, the plate I used is approximately 10 inches in diameter as shown in Fig. 3. In the final picture, the shot was taken directly on top of the plate using my Canon PowerShot SX530 HS camera. The lighting we did in the side did not affect the final picture since it was taken from the top, but the initial setup was done to be able to capture the flow from a variety of different angles. The focal length used was 4.3 mm with an F number of f/3.4. The exposure time was 1/30 sec with as ISO equal to 200. Since the flow was fairly slow with no sudden movements, I did not have to be strict with these settings and they were the ones I got from using the Auto feature. The lens were 4.3-215.0 mm.

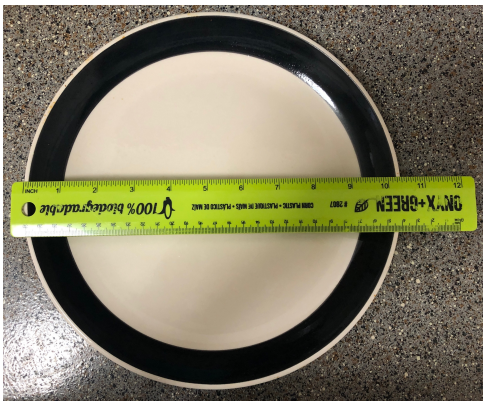


Figure 3. Showing the scale of the picture.

FLOW PHYSICS

The main flow phenomenon that was demonstrated in this experiment is most likely due to Marangoni (surface tension driven) flow. m&m candies are mostly made of food dye and sugar from candy coating. Both of these two components are known to be surfactants, substances that reduce the surface tension of any liquid that it is dissolved in. Surface tension is a type of force per unit length that acts along an interface of two immiscible fluids [1]. For a surface-tension-driven flow to happen, there must be a free liquid-fluid interface as in our case. Because of the circle geometry of the candy ring, the surface tension in the center of the m&m candy ring is higher than that of the outside. The driving force of the higher surface tension caused the dyed fluid to get drawn to the center. The maintained radial symmetry is probably due to how the difference in surface tension is also the same radially[3].

There is little reliable information published on this specific experiment, so the above explanation remains a possibility. Another possible explanation for this phenomenon is water stratification. This is when water masses with different properties refuse to mix due to some invisible "barriers", which is why the colors don't mix while moving to the center of the plate [2]. The movement itself is caused by a process called diffusion, as the sugars and food dye in the m&m candies start to dissolve, the molecules move from higher to lower concentration as shown in Fig. 4. Note that the time it took for the food dye to reach the center of the plate was around 20 seconds, which means it had a fairly slow flow speed. After another 20 seconds, the flow started to mix and became one dark muddy fluid.

Figure 4. Showing the dissolved food coloring moving to the center.

PHOTO EDITING

The dimensions for the original photo were 4352 × 3184 pixels with an image resolution of 180 Pixel per Inch. For post-processing, I wanted to do some significant changes to the original picture since I knew I was not satisfied with how it came out in terms of appearance. The food coloring mixed a bit too much to the point that it started getting a bit dark and muddy and it did not look like a pleasing picture. It was then that I had an idea that instead of doing the experiment again, I could obtain some amazing result if I tried to invert the colors. By inverting them, I was able to get the exact opposite of my initial critique.

The muddy colors turned to vibrant ones and gave a sort of sci-phi feeling to the picture. After I saw that, I knew that with a bit more editing I would have the perfect picture that I wanted from this experiment. I completed the editing by adding some contrast to the picture with settings as shown in Fig. 5, and then making the surrounding background completely black to have the focus be entirely on the vibrant flow. A common critique that I got from class is that I should have erased the black spots in the white section of the picture. I tried editing that in photoshop but failed to get a satisfying result that looked like a professional work, so I decided to keep it as it is.

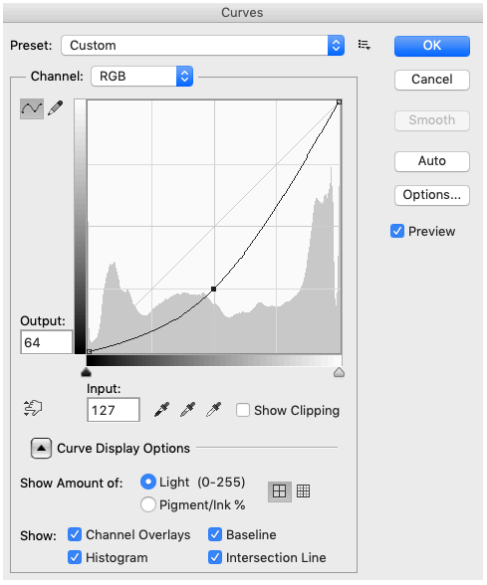


Figure 5. The curve settings used to change the contrast of the image.

CONCLUSION

This assignment was my first time trying to take a professional photo. I learned a lot of valuable information while doing this experiment and even while editing. I think that the set up I used, although minimal, was adequate for this experiment. However, to do more complex experiments in the future, I need to buy more professional equipment like a tripod and some proper flashlights. I received positive critiques about the editing for my picture, most are complimenting the choice to invert the flow colors. It is my hope to learn more about photography as well as the different flow physics in future assignment of this class.

REFERENCES

[1] Chakraborty S. (2013) Surface-Tension-Driven Flow. In: Li D. (eds) Encyclopedia of Microfluidics and Nanofluidics. Springer, Boston, MA. Available at: https://link.springer.com/referenceworkentry/10.1007%2F978-3-642-27758-0_1510-2#howtocite [Accessed 1 Oct 2019].

[2] Encyclopedia of Ocean Sciences (Second Edition). 2009, Pages 172-180: doi: https://doi.org/10.1016/B978-012374473-9.00646-9

[3] Professor Jean Hertzberg's note (Jan 21, 2019): http://www.flowvis.org/2018/11/22/team-third-matthew-finney/