Team First

Fall 2019

MCEN 4151-001: Flow Visualization

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INTRODUCTION

For the "Team First" assignment, we were asked to once again, take a picture that demonstrates a special phenomenon of any fluids, while also having the picture itself be pleasant to look at by demonstrating professional photographing and editing skills. Our team decided to build-up on a previous idea one of our members, Jason Fontillas had for the past assignment. We made multiple takes of squirting different colored Indian ink out of a syringe while submerged underwater. For the result that I decided to go with, we used two Red and Black colored ink and visualized the flow of their interaction with each other. The final flow resembled a beautiful smoke and depicts the Rayleigh-Taylor Instability. This experiment was a collaborative work with Antonio Gueretta, Salah Ammar, Abdullah Alsaffar, Jason Fontillas.

EXPERIMET SET UP

We had several ink colors for the experiment which were Red, Blue, Black, and Orange. We injected different colors to different 5” syringes. The goal was to try and mix different color combinations using different flow motions. The image that I picked in the end was the of the experiment in which Black and Red ink colors were chosen. The colors were squirted to a small aquarium that was filled with water. We placed a white board behind the tank for a smooth background. We used two light sources, one from behind and one from the right side. To get a since of scaling, the light used in the left side of the setup is about 16” long. A sketch and a photo of the entire setup is shown in Fig. 1.

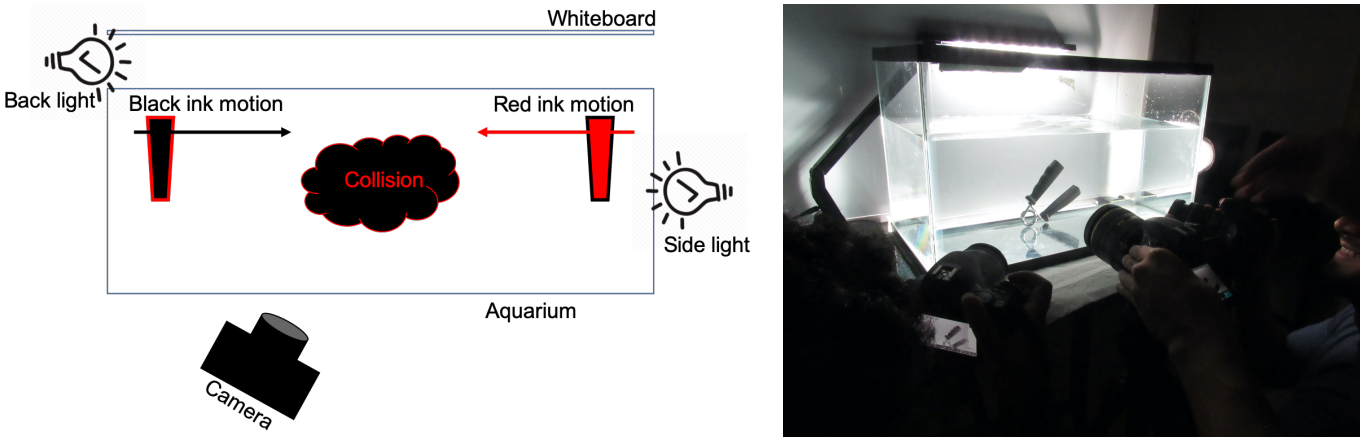

Figure 1. A sketch and a photo of the used setup.

In this experiment, the team members switched places on who is filling the tank with water each time and everyone contributed to that. In the end, I had Abdullah Alsaffar and Salah Ammar assist me with squirting the colors into the tank. One of them held the Black ink in the left, and the other held the Red ink in the right. Then, both of them squirted the syringes slowly and started moving to the center until the two ink colors interacted together. Other than the two light sources in the diagram, we turned the room lights off and blocked the curtains. However, some of the natural light sneaked in. The shooting was done by my Canon PowerShot SX530 HS camera, with lens 4.3-215.0 mm. For the final image, the settings were: Focal length 5.98 mm, exposure 1/60 sec, f/7.1, and an ISO of 1600. The FOV in the final picture is about 4 inches. The shot was taken from an angle slightly to the left of the center of the tank.

FLOW PHYSICS

The main flow phenomenon depicted in this experiment is the Rayleigh-Taylor Instability. This phenomenon mainly demonstrates the flow movement of two fluid with different densities [1]. The heavier fluid which have highest density (Indian ink), will move through the fluid with the lowest density (water). A shear force will be exerted on each fluid by the other during the collusion. The interaction caused by this force can result in a variety of interesting shapes. To analyze the flow in more details, Reynolds number is approximated as follow: $Re = \frac{\rho V D}{\mu}$, were ρ is the density of the fluid, V is the velocity of the fluid, D is the characteristic length, and μ is the dynamic viscosity.

Table 1. Data for the Red and Black ink flow.

	Black Ink	Red Ink
ρ (kg/m^3)	1074.3	1012.5
V (m/s)	0.29	0.26
D (m)	0.024	0.04
μ (Pa.s)	5.751×10^{-3}	1.114×10^{-3}

The velocity and length values were approximated by analyzing the subsequent pictures using photoshop measuring tools, while the density and viscosity values for obtained from [2]. Using these values, we can approximate Reynolds number to be:

$$Re_{Black} = \frac{(1074.3)(0.35)(0.04)}{(5.751\times10^{-3})} = 2615 \qquad Re_{Red} = \frac{(1012.5)(0.155)(0.04)}{(1.114\times10^{-3})} = 5635$$

The values here indicate that the Red flow is turbulent, while the Black flow is transitioning from laminar to turbulent. This can be verified by looking at the flow as time progresses. A photo showing the moment after the collision is shown in Fig. 2.

Figure 2. Showing the interaction of the two colors at the start of the collision.

It can be shown that the Red ink flow is more chaotic compared to the Black flow.

PHOTO EDITING

I used Adobe Photoshop CC 2019 to edit my photo. As a starter, I was hoping to make the Black and Red colors more dominant in the picture. I thought the red in the original looked more like orange and the black like brown. I had the following two settings in Photoshop to adjust the colors using the Color Balance function as shown in Fig. 3.

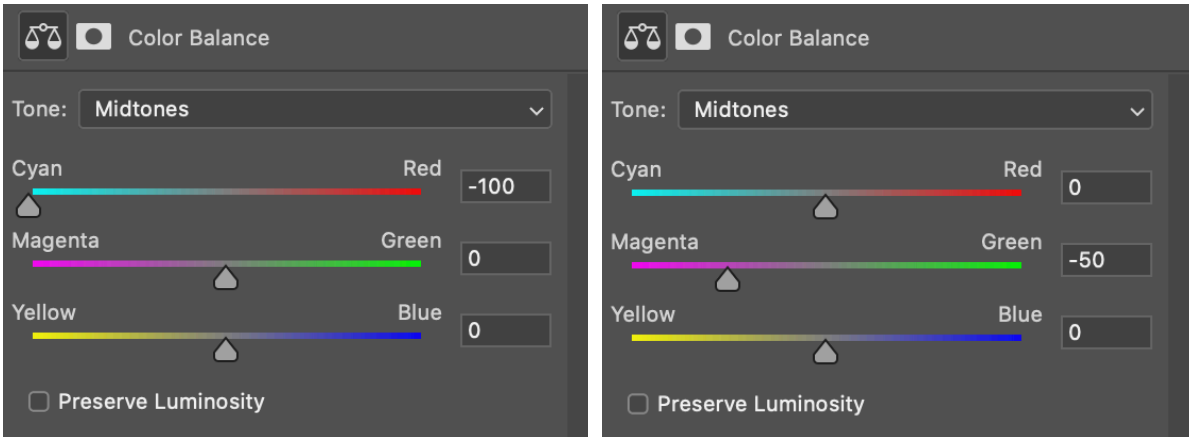

Figure 3. The color balance settings used to adjust the colors.

Finally, I wanted to delete some of the grains in the picture. Those were caused by some scratched on the surface of the tank. There was also some light reflection which I though was distracting. I used the Photoshop tool "Spot Healing Brush" to fix these spots. I finished by cropping the top right corner out since it showed the outside of the tank. A comparison between the original and the final edited image in shown below in Fig. 4

Figure 4. The original photo (left) vs. the edited image (right).

The dimensions of the final photo were 4617 px x 3456 px. The resolution was 180 pixel per inch.

CONCLUSION

In this assignment, I further developed my photography skills a lot of by understanding more about the effects of various camera settings. Most students complimented my choice of color editing which increased my confidence in artistic judgment. Overall, I really like how this image turned out. I can get a feeling that the two colors are kind of fighting each other's which is fitting for a collision between a turbulent and mixed flow. It's also interesting how the middle of the picture is chaotic while the edges give a calm feeling.

REFERENCES

[1] https://www.physicscentral.com/explore/action/mixing-physics.cfm
[2] https://wiki.anton-paar.com/en/ink/