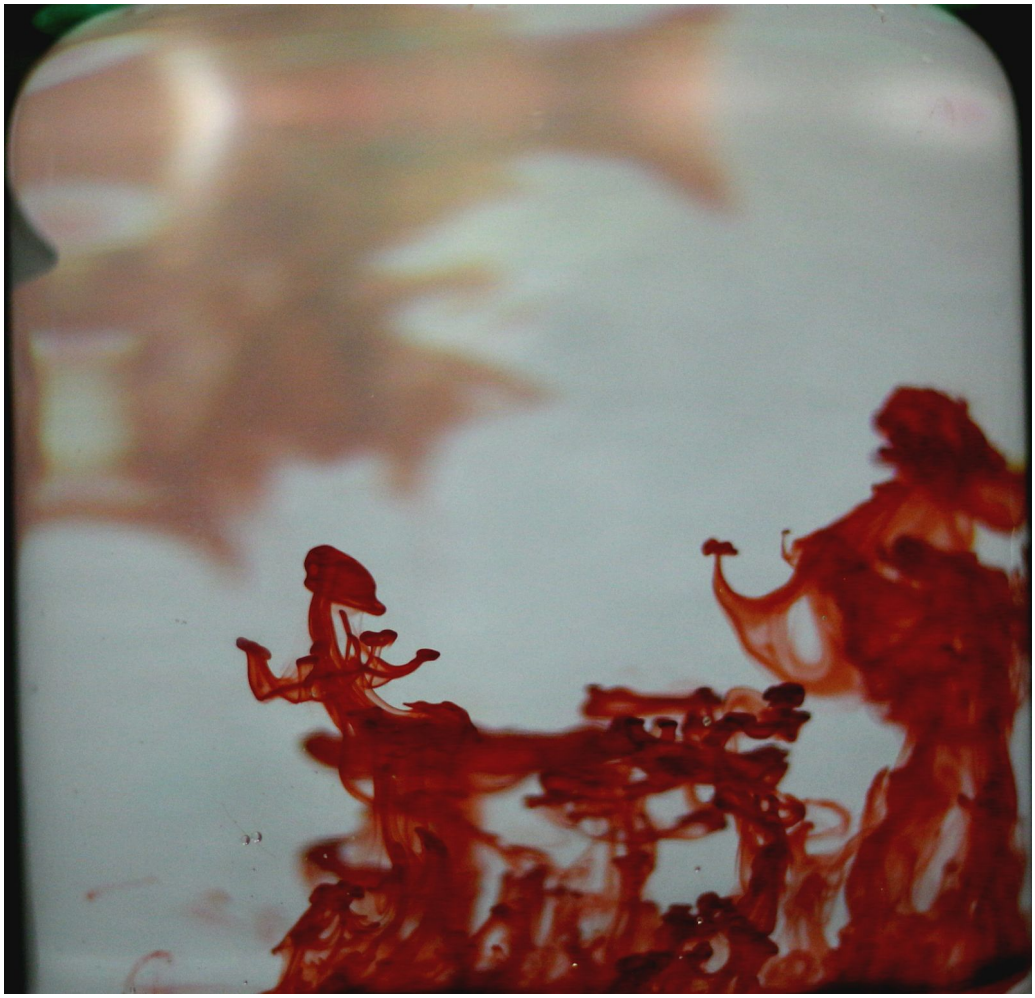
Team Third Report
MCEN 4151



Yousef Shashtari
With the help of Team epsilon
May 1st, 2018

Me and my teammates were trying to perform an experiment for the third team assignment in flow visualization class. The initial idea was to understand how oil mixes with water. We filled a glass container with water and squirted some oil on the water. We got very nice results and took many pictures of the flow of oil in water. However, we thought about adding some drops of food dye to the mixture to make it more interesting. Eventually, we emptied the container and filled it with water only and dropped food dye on it.

The use of food dye was to see how it mixes with water and to see the beautiful flows it creates. The team spent many hours on the project since we had to try many ideas. This image was taken by Phil's camera. Every team member was responsible for some parts of the project. Eric Robinson was trying to squirt the oil on the water, Zachary Marshall was holding the flashlight, Phil Nystrom and Luke Collier were trying to take pictures of the experiment, and finally I was dropping the food dye on the water.

Figure 1 shows the Rayleigh-Taylor instability that occurs when dropping food dye on water. The dye forms in a mushroom shape once it emmerses in the water. This instability happens when there are two different liquids that have different densities or pressures. In our experiment, the two liquids had both, pressure was different because we squeezed the food dye bottle very hard and the food dye already had a lower density compared to water.

We had to repeat the experiment couple of times since not every attempt showed a beautiful result. I chose this image particularly since it was the best image that showed the instability. More importantly, this image was chosen since the dye shadow in the background looked like a red fish. This can be seen in the top left corner of the image. Also, a reflection of the glass container appeared on the fish and actually added a beautiful touch to the image. Since Rayleigh Taylor instability is so complicated, I will not be able to discuss it in this report as it is beyond my knowledge. However, I will be discussing about the Reynold’s number of the food dye. As I mentioned above, the dye had a higher pressure compared to the pressure of the water surface. Therefore, the flow of the food dye was turbulent before it touched the surface of the water. The following paragraph will be focusing on calculating the Reynold’s number of the flow.

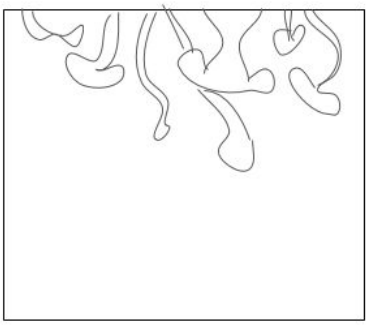


Figure 1 Rayleigh-Taylor Instability

There were many forces acting on the flow of the food dye. One of the forces is the force of gravity. Another force is the shear force between the water and the dye, which was responsible for making the mushroom shapes of the dye. Shear force was also responsible for guiding the direction of the flow. Since I said that the flow was turbulent, Reynolds number should be higher than 2100. Before calculating Reynold's number, I will discuss the differences between laminar and turbulent flow.

Figure 2 clearly shows differences between laminar and turbulent flows. Figure 2 part (A) shows the flow of a laminar flow where the fluid particles flow in parallel lines. On the other hand, figure 2 (B) shows the flow of a turbulent fluid flow. In this case, fluid particles flow in random directions, which is the opposite of the first case. In order to have a laminar flow, the flow should have a Reynold's number of 2100 or less. While turbulent flows have a Reynold's number of 4000 or higher. There are some flows that have a Reynold's number between 2100 and 4000. These types of flows are considered both turbulent and laminar flow since the are turbulent in some part of the flow and laminar in the other part.

The food dye was flowing directly from a 2.5mm hole, and the velocity of the dye was approximately 2m/s. I couldn't find the kinematic viscosity of the food dye, so I will use the viscosity of water which is $1.004 * 10^{-6} m/s^2$. I calculated Reynold's number using the following equation:

$$Re = \frac{U*D}{\nu} = \frac{2\ m/s * 0.0025m}{1.004*10^{-6}\ m^2/s} = 4980$$

Hence, the flow was a turbulent flow since its Reynold's number is larger than 4000. However, I have to note that this is not the actual Reynold's number of our flow since I used the viscosity of water instead of the food dye.

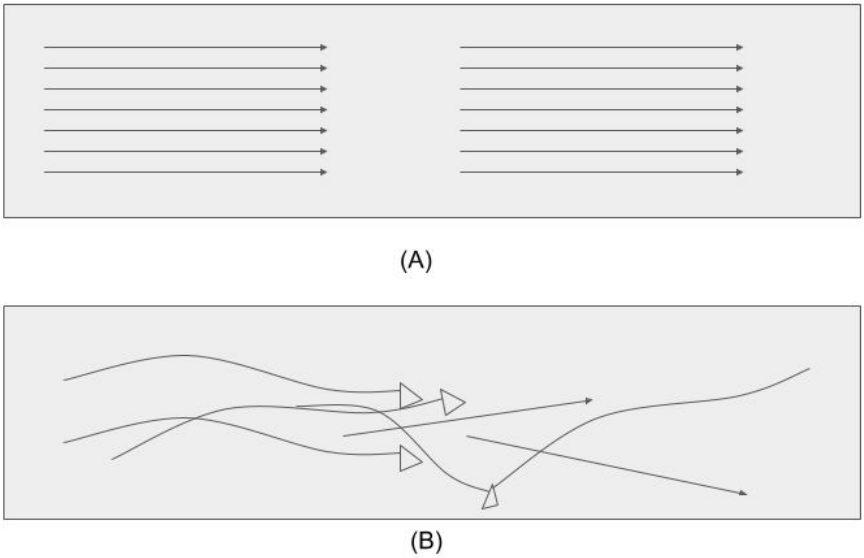


Figure 2: Laminar vs Turbulent Flow

As I have discussed in the report, dye was used to visualize the flow. I bought the food dye from king soopers grocery store, and it was a product of Kroger company. The experiment was performed in the ITLL 3D printing room and we used iPhone's flash as the lighting source.

This image was taken using Phil's camera which was a Canon 6D DSLR camera. We were using a fixed lens that couldn't zoom, and it was a 50mm lens. Although we used an iPhone flash as a lighting source, we also set the aperture of the camera to f/1.8 to make sure that the lens was collecting enough lighting. Finally, ISO was set at 100. The edited images has 1689*1628 pixels, while the original image has 4000*2671 pixels. The object was 0.3m to 0.4m away with a field of view of 0.25m.

Regarding post processing, I had to crop the image in order to make it more focused on the idea of the project. I also increased the contrast and decreased the brightness. Also, I flipped the image vertically since it looked better that way and it made it easier to see the fish in the background. Figure 3 shows the original image, while the image in the cover page is the edited version.

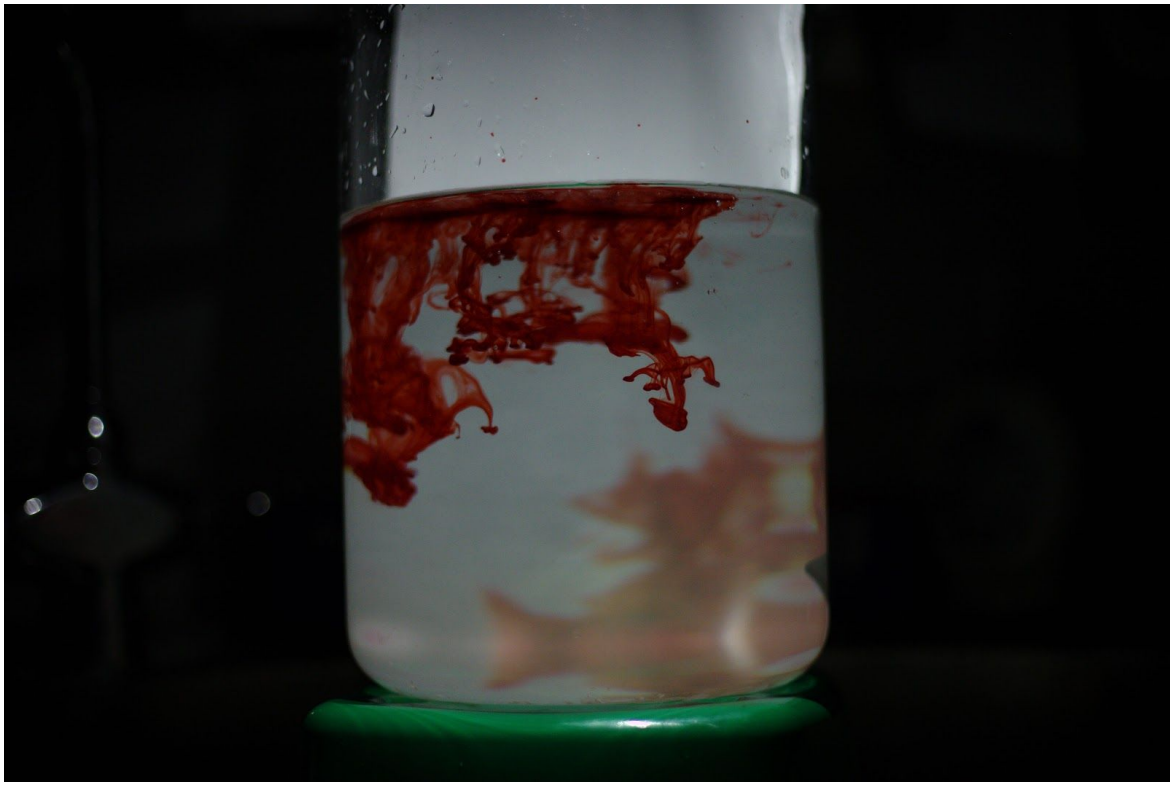


Figure 3: The Original Image Before Post Processing

Finally, the image reveals how food dye acts when it mixes with water. It also shows Rayleigh-Taylor instability and its mushroom shape. I believe that the physics is clearly shown in the image although it might not be easy to understand. To improve the image, I would like to use different colors of food dye and I would like to change the container and use a bigger one.