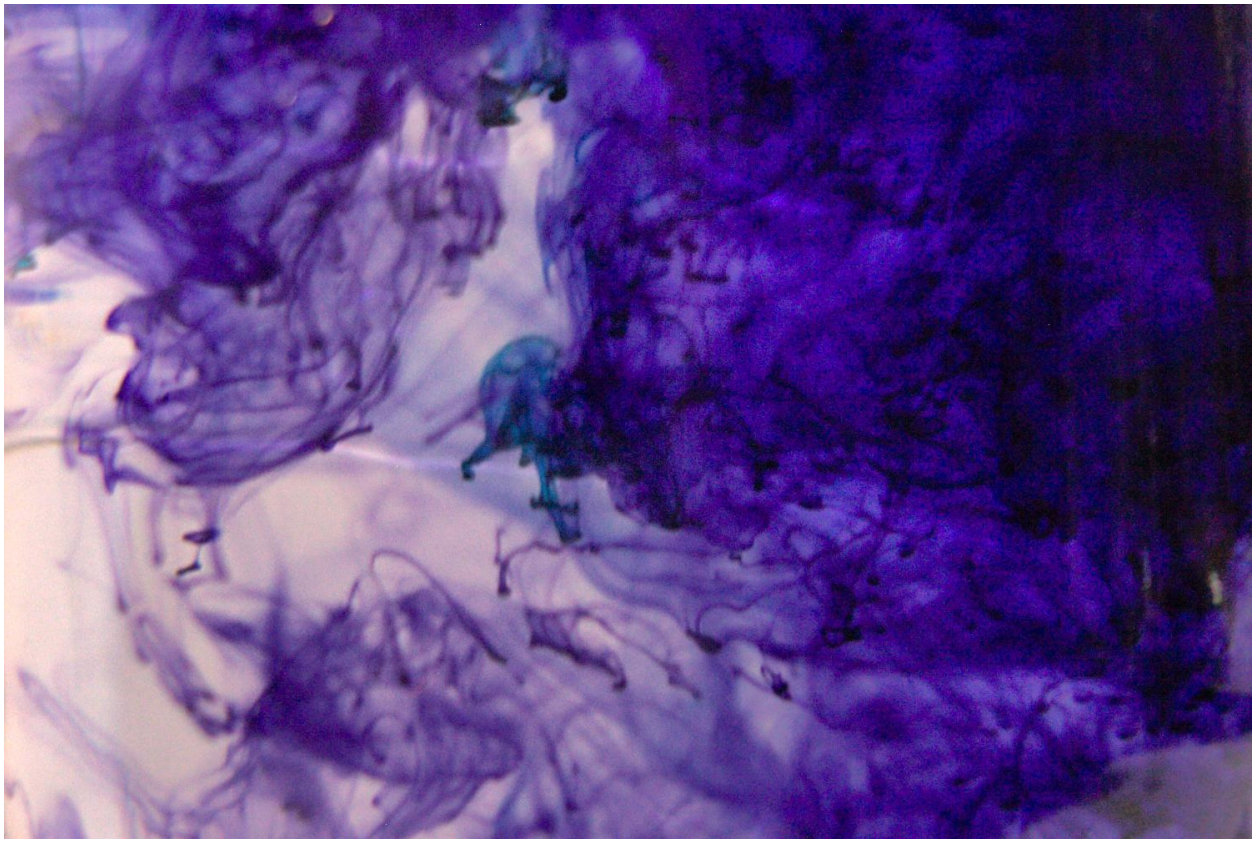
Chromatic Kaleidoscope



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I Introduction

Rayleigh-Taylor instability is depicted in this image using three liquids with differing densities. Likewise, the photographic and visualization techniques are used to capture the science behind the flow. This image was taken for the Team Second assignment for the Flow Visualization course at the University of Colorado Boulder. The experiment was conducted alongside Jonathon Gruener and Ari Matrajt Frid.

The image shows the resulting flow that occurs when food dye mixed with oil is poured into a mason jar filled three fourths of the way with warm tap water. When the oil and food dye is poured into the water, the food dye drops out of the oil and mixes with the water over time. This created the swirls or “fireworks” of color seen in the photograph.

II Flow Apparatus

This experiment was conducted using warm water, avocado oil, and food dye. A mason jar was filled around three quarters of the way with warm tap water. Around half a cup of avocado oil and 10 drops of food dye were put in a separate glass container. The avocado oil and food dye were then mixed to break up the food dye into smaller droplets. The food dye did not mix with the oil. The glass containing the oil and food dye was then poured into the mason jar. Over time the food coloring dropped and mixed into the water, while the oil stayed floating on top. The experiment setup to capture the image is shown in **Figure 1**.

Figure 1: Diagram of experiment setup

The image depicts both chemistry and fluid dynamics. The chemistry of the experiment explains why the food coloring was able to drop out of the oil and react with the water. Oil is hydrophobic, meaning that it does not mix with water. This is because oil is made up of hydrocarbons that are non-polar, so it does not have the strength to break up the hydrogen bonds between water molecules[1]. On the other hand the food coloring is a water-based liquid, meaning it is primarily made up of water molecules. Therefore, the oil reacts with the food dye just like it would with the water, not mixing. Despite mixing up the oil and food dye to break up the droplets, the two materials would not mix.

This leads to the fluid dynamics part of the experiment. The flow created from this experiment is called the Rayleigh-Taylor instability. This is an instability between two fluids of different densities which occurs when lighter fluid pushes on a heavier fluid[2]. In this case the oil is less dense than the water so it floats atop the water in the mason jar. The food dye, being water based, is more dense than the oil so over time the droplets sink to the bottom of the oil. Once the droplets of food coloring become large enough they drop out of the oil and into the warm water below. The water and food dye react because the food coloring is of similar density and polarity. As the dye reacts with the water it spreads throughout the jar creating the swirls shown in the image.

III Visualization Technique

The visualization of this experiment was achieved using a clear glass mason jar so that the vibrancy of the colors were easy to capture. The jar was filled three fourths full with water to allow for a large space for the reaction between the water and food dye to take place. It took about two minutes for enough of the food dye to drop into the water and get the desired effect that you can see in the image.

To attain the desired lighting, this experiment had both an overhead light and a light shined directly on the jar from next to the camera. The light shining from next to the camera helped to avoid a shadow casted from the camera itself. A white background was used to reflect the light back onto the jar.

IV Photographic Technique

The image was captured on a Canon EOS 5D camera with a 28-200 mm lens. This lens has an aperture range of f/3.5-5.6 and a filter thread diameter of 72 mm. The distance from the camera to the object was about a foot in length and had a field view of about twelve degrees. The exposure was 1/50 seconds, the focal length was 50 mm, aperture f/4.5, and the ISO was 800. I

chose these settings to capture the motion and vibrancy of the food dye. The original image is 5616 x 3744 px. The final edited image is 1497 x 1001 px. The original and edited photos are shown in **Figure 2** and **Figure 3** below, respectively.

Figure 2: Original Image

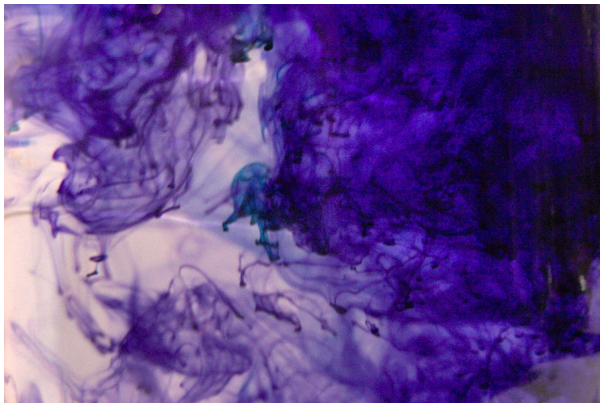

Figure 3: Edited image

The photo editing software used to get the final image was Darktable. First the image was cropped using the crop tool so that only the flow of the food coloring in the water was shown. This enhanced the image because it cut out the oil floating on top and made the image more vibrant. The tone curve was then adjusted to the left. The exposure, highlights, and shadows were all increased. Finally, the sharpen tool was used to sharpen the image to create better focus. The goal was to make the flow apparent while making the colors from the food dye as vibrant and eye catching as possible.

V Image Analysis

The image provides an example of _. I really like the vibrancy of the colors in the final edited image. I believe that the lighting for the image could have been a little brighter to better show the highlights and shadows in the experiment. I believe the flow of the food dye is really well captured because there is a gradient from where it is light and there is less dye to where the image is darker and there is more dye. I feel as though the focus could have been a bit more sharp to make the flow more visually appealing.

This experiment was done using only three materials that can be found in almost anyone's pantry. The use of these materials to create a flow phenomenon demonstrated both physics and chemistry. To further develop this experiment, I would use different colors with more vibrancy. I would also experiment with different oils and water temperatures to see if that had an effect on the flow of the food coloring.

VI References

- *Make fireworks in a jar*. Make Fireworks in a Jar | Ontario Science Centre. (n.d.). https://www.ontariosciencecentre.ca/science-at-home/diy-science-fun/make-fireworks-in-a-jar
- Wikimedia Foundation. (2023, September 19). *Rayleigh–Taylor instability*. Wikipedia. https://en.wikipedia.org/wiki/Rayleigh%E2%80%93Taylor_instability