Team Second Report

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MCEN 5151 Flow Visualization

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Introduction

This assignment was the second team assignment of MCEN 5151. My team consisted of myself, Sierra Greeley, Ari Matrajt Frit. This experiment involved pouring oil and food coloring into a mason jar filled with warm water. The goal of this experiment was to visualize an example of the Rayleigh-Taylor instability.

Flow Apparatus

The flow apparatus for this experiment was simple, consisting of a mason jar. The jar was filled with warm water. Then, avocado oil and food coloring were mixed in a bowl. The oil and coloring mixture was poured into the mason jar. [1] Pictures were taken as strands of the food coloring descended. A sketch of the apparatus is shown below.

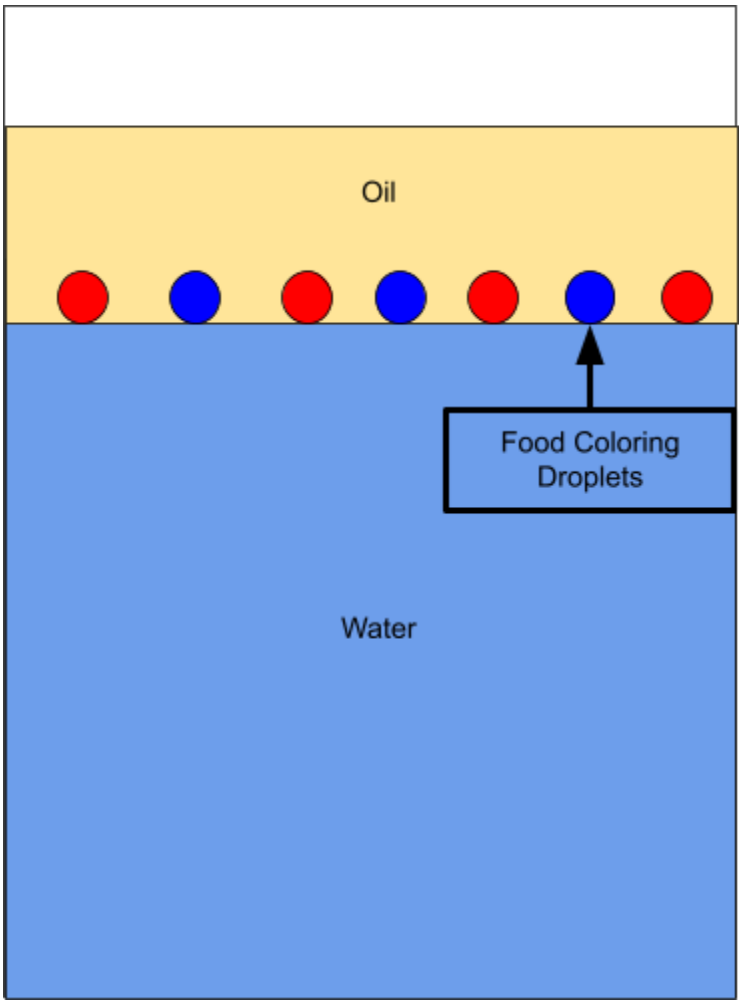


Figure 1: Diagram of experimental set up

Fluid Dynamics

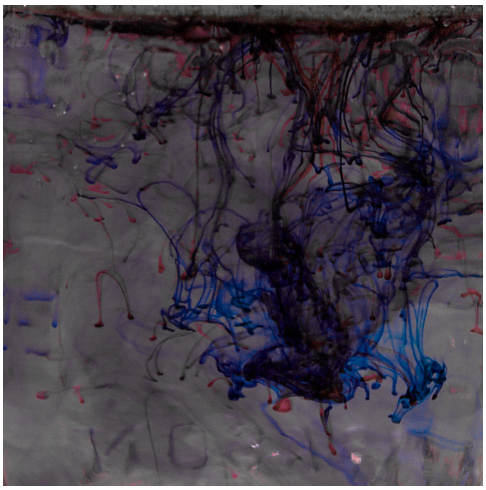
The water fireworks experiment is an example of the Rayleigh-Taylor instability. The Rayleigh-Taylor instability is an instability that occurs at the interface between two fluids of differing densities. The lighter fluid pushes into the heavier fluid, causing spikes to occur and the layers to intermix. As the perturbations along the interface continue to grow, they begin to pass through the interface and form mushroom-shaped tendrils. [2] This is visible in the photos.

Visualization Technique

The visualization technique for this experiment was relatively simple. A mason jar was obtained and filled with warm water. Simultaneously, avocado oil was poured into a bowl along with red and blue food colorings. They were mixed together to cause the food coloring to break into small suspended droplets. The avocado oil and food coloring were then gently poured into the mason jar. A white backdrop was used during the experiment. Additionally, the lighting set up consisted of overhead lighting, with a small LED light directly above the jar.

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 6 inches with a field of view of about 12 degrees. The exposure was 1/30 sec, the ISO was 500, and the focal length was 200 mm. The camera was set to aperture priority. I chose these settings to capture the motion of the image without compromising the vibrancy of the color. The original image was 5616 x 3744 px. My edited image was 978 x 978 px. The original and edited pictures are shown below.



Figures 2 and 3: Original and edited images.

I used darktable to edit my image. This week, I chose to really try to change my photo a lot with the editing. I cropped and rotated the image to show only the fluid mechanics and nothing else. I turned off all of the colors and turned the photo black and white. Then, I turned up the blue and red/pink sliders. This helped make the colors of the food dye really pop. Overall, I am really happy with how it turned out. While this isn't how I have edited my photos in the past, I am very happy with how this turned out.

Conclusion

This image is a great example of the Rayleigh-Taylor instability. While this is a simple experiment, the Rayeligh-Taylor instability is extremely commonplace. I think that this experiment turned out well and I am very happy with the photos. I liked the raw image but I think my editing totally changes how the image is perceived. I have definitely grown in my skills in darktable which is awesome. If I were to take this experiment further, I think that using a slow-motion camera could really capture the smaller level instabilities that cause the fireworks themselves.

References

[1] Newsome, B. (2023, March 31). *Fireworks in a Glass*. Fizzics Education. https://www.fizzicseducation.com.au/150-science-experiments/water-science-activities/fireworks-in-a-glass/

[2] D.H. Sharp,An overview of Rayleigh-Taylor instability,Physica D: Nonlinear Phenomena,Volume 12, Issues 1–3,1984,Pages 3-18,ISSN 0167-2789, https://doi.org/10.1016/0167-2789(84)90510-4.