MCEN 5151-003 Flow Visualization — Team Third

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In this project, I aimed to capture a fluid phenomenon in a controlled setting, emphasizing fundamental concepts of fluid mechanics. The setup for this experiment involved pouring creamer into a cup of coffee, showcasing a range of dynamic fluid behaviors. The objective was to highlight the effects of diffusion and mixing, which create intricate patterns as the creamer blends with the coffee. Additionally, the experiment captured fascinating phenomena such as shockwave formations and the nice looking phenomena of a droplet bouncing off the coffee surface. This setup provided a cool visualization and scientifically rich representation of fluid mechanics principles.

The setup for this experiment consisted of creamer being poured into a big cup of coffee. A simple experiment setup was created using a white lamp for consistent illumination and a black table as background, ensuring clear contrast between the coffee, creamer, and the background. The experiment was designed to capture the mixing and diffusion patterns, but I ended up capturing along with other fluid phenomena such as the shockwave and the bouncing of a droplet off the coffee surface.

In this scenario, the primary fluid mechanics phenomena are the diffusion of creamer into the coffee and the interactions at their interface. As the creamer blends, diffusion creates diffusing patterns and surface tension effects govern the behavior of droplets bouncing off the coffee surface. Additionally, the shockwave created as the creamer interacts with the coffee highlights dynamic fluid responses to sudden disturbances.

This controlled setup is very easy to replicate, although the captured patterns will always look difference due to the chaotic nature of turbulence.

In this experiment, I employed a simple yet effective visualization technique using the natural properties of coffee and creamer, without any additives or dyes, to highlight the dynamic interactions between the two fluids.

To improve the visibility of the fluid dynamics, I used a white lamp as the main light source. This lamp provided uniform illumination, eliminating shadows and allowing for a clear view of the coffee's surface and the subtle patterns formed by the creamer. The black background created by the table enhanced the contrast, emphasizing the interaction between the coffee and creamer. This setup effectively highlighted the diffusion patterns, the bouncing droplet, and the shockwave dynamics, creating a niche visualization of the fluid's behavior.

For this visualization, I used a Fujifilm X-T2 digital camera to capture the image, which offers excellent image quality and versatility. The original image dimensions were 4000 pixels in width by 6000 pixels in height, providing a high-resolution capture of the fluid dynamics. The field of view was approximately 30 cm by 20 cm, allowing for a detailed view of the coffee, creamer, and their interactions. I positioned the camera about 35 cm away from the coffee, which provided an optimal distance to focus on the diffusion patterns, bouncing droplet, and shockwave dynamics without distortion.

I used a 35mm lens for this shot, which provided a balanced perspective for the close-up, primarily because it is the only lens I have. I adjusted the exposure settings to ensure proper illumination: an aperture of f/5.6, a shutter speed of 1/125 seconds, and an ISO setting of 200. These settings minimized noise while effectively capturing the diffusion patterns, the bouncing droplet, and the shockwave dynamics in the coffee.

The original image was cropped to focus only in the liquid region, removing the mug's edges but making sure to capture the shockwave, the mixing patterns and the bounding droplet. During post-processing, I increased the contrast, highlights, and black point to

achieve a strong black background. Additionally, I boosted the warmth and brilliance to accentuate the colors of the coffee and creamer. This editing was done using an iPad photo editor, which is easy to use and provides really nice effects.

(a) Original Image

(b) Final Processed Image

Figure 1: Comparison of original and final processed images.

The image captures the interaction between the coffee and creamer, highlighting fluid dynamics principles such as diffusion, mixing, and surface tension. The creamer blends

into the coffee, creating artistic patterns, while the bouncing droplet and shockwave further illustrate dynamic fluid behavior. The lighting and contrast adjustments effectively emphasize these phenomena, with the enhanced contrast bringing out the diffusion patterns and the sloping of the liquid surface. The variations in color and form reveal the different physics implied on the phenomena that have been previously exposed.

To develop this idea further, I would like to explore using different liquids with varying viscosities or surface tension properties to see how they affect the mixing and diffusion behaviors. Additionally, experimenting with different liquid temperatures could provide further insights into the fluid dynamics in function of the viscosity. It could also be interesting to incorporate a rotating magnet at the bottom of the cup, which would create cool rotating mixing patterns.

Bibliography

[1] G. K. Batchelor, *An Introduction to Fluid Dynamics*, Cambridge University Press, 1967. https://www.cambridge.org/core/books/an-introduction-to-fluid-dynamics/18AA1576B9C579CE25621E80F9266993. DOI: 10.1017/CBO9780511800955.