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Professor Sunberg
MCEN 4151 – Flow Visualization
02 November 2026

Team Second Report

The second team assignment for this course followed the same general guidelines as the Get Wet and Team First assignments. Although it was intended to be a group assignment, the flow visualization detailed in this report was completed individually. This project used two materials: glow sticks and 3% hydrogen peroxide. The initial plan was to pour hydrogen peroxide through the glow stick chemical (phenyl oxalate ester) to activate it, but after many failed attempts at opening a glow stick tube without breaking the inner glass vial, a different approach was taken. The remainder of this report will describe the methodology and procedure of the experiment as well as analyze the flow on a scientific level.

To create this flow visualization, the contents of numerous severed glow stick tubes were emptied into a sink bowl (figure 3). Using the emptied tubes, the colors were swirled together to create an aesthetically pleasing look (figure 4). Afterward, hydrogen peroxide droplets landed in the glow stick mixture from above. Because the lighter peroxide was introduced above the heavier phenyl oxalate ester (POE), the solution can be classified as gravitationally stable (Elliott, Vasquez, para. 1). After dripping the hydrogen peroxide from above, it was released from the sink's edge and accelerated into the glow stick liquid in pulses. Below, two dimensionless numbers can be estimated: Reynolds Number (Re) and the Atwood number. The Reynolds number is calculated as $\rho UL/\mu$, where ρ is density, U is injection velocity, L is characteristic droplet length, and μ is dynamic viscosity. The Atwood number is calculated as $(\rho1 - \rho2) / (\rho1 + \rho2)$ where $\rho1$ is the heavier fluid and $\rho2$ is the lighter fluid.

Density – $\rho1$ Phenyl Oxalate Ester (kg/m^3)	Density – $\rho2$ 3% Hydrogen Peroxide (kg/m^3)	Velocity – U H.P. into P.O.E. (using sqrt(2gh) where h = 5 in. = 0.127 m) (m/s)	Droplet Size – D (m)	Dynamic Viscosity μ (Pa*s)
1257	1010	1.58 m/s	0.004	0.001

Table 1

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Reynolds Number
6383.2

Table 2

A Reynolds Number 6383.2 indicates strong inertial forces over viscous forces. The hydrogen peroxide dominates over the viscous POE as it cuts distinctly through it with each pulse.

Atwood Number
0.109

Table 3

The calculated Atwood number (Wolfram Research) is particularly interesting since it is small relative to the Atwood scale of 0 to 1. This points to a low density-difference system. In figures 1 and 2, the density difference is still visually apparent even with such a small Atwood number. It can be seen by examining the small, spherical hydrogen peroxide droplets scattered throughout. The Plateau-Rayleigh instability is present. This instability is described by "A liquid jet…falling vertically under gravity…liquid length increases and reaches a critical value. At this critical value, the jet loses its cylindrical shape as it decomposes into a stream of droplets" (Breslouer, para. 1). See figures 5, 6, and 7. Here, three timestamps (with each image taken approximately 2 seconds apart) display one stage of the Plateau-Rayleigh phenomenon. A jet of peroxide accelerates through the POE and "varicose perturbations" (Breslouer, para. 3) quickly form until the critical length is reached, which results in the final droplets seen in figure 7.

The raw image (figure 1) was a snapshot from a video taken on an iPhone 15 Pro. The only light available was from the activated POE in the sink as the video was filmed in a dark bathroom. Flash photography was not used. The final image was fully edited on the iPhone using the Photo app's available features including the "Clean Up" option, which was used to remove the splattered particles surrounding the main visualization. The spatial resolution of the final image was greatly affected by motion blur, pixelation, and poor focus. The blur was slightly reduced by increasing the sharpness and definition of the image. In terms of temporal resolution, (1/29.9) x 1000 provides ~33.4 ms between frames.

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Raw Image Size	Final Image Size
1179 x 2556	1179 x 2494

Table 4

Video Resolution	Frames per sec.	Focal Length	Aperture
1080p	29.9	24 mm	f/1.78

Table 5

The final image was a successful completion of the Team Second Assignment. The strengths here were the aesthetics of the visual and the instabilities captured. The weaknesses were in image capture and post-processing. Attempts were made to recover details from the images taken from the original video, but they ultimately did more to increase contrast than to recover details. In the future, more research will be done into photographing luminosity in the dark and into post-processing high-contrast images.

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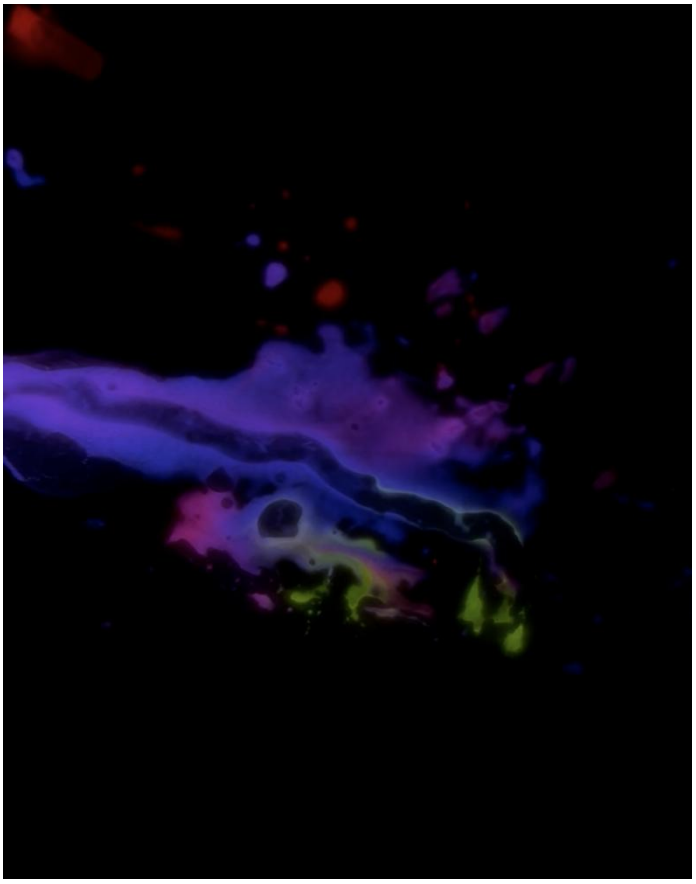


Figure 1

**Note that this raw image does not hold the correct size of the original raw image, please refer to table 4 for correct value*

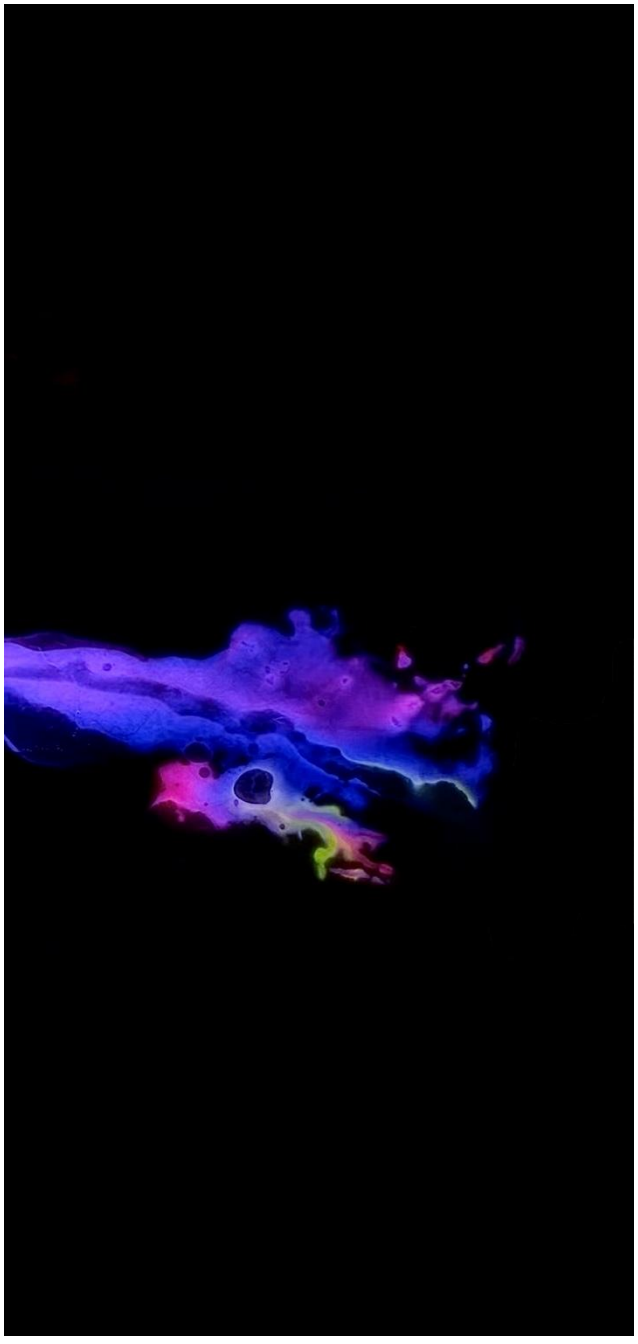


Figure 2

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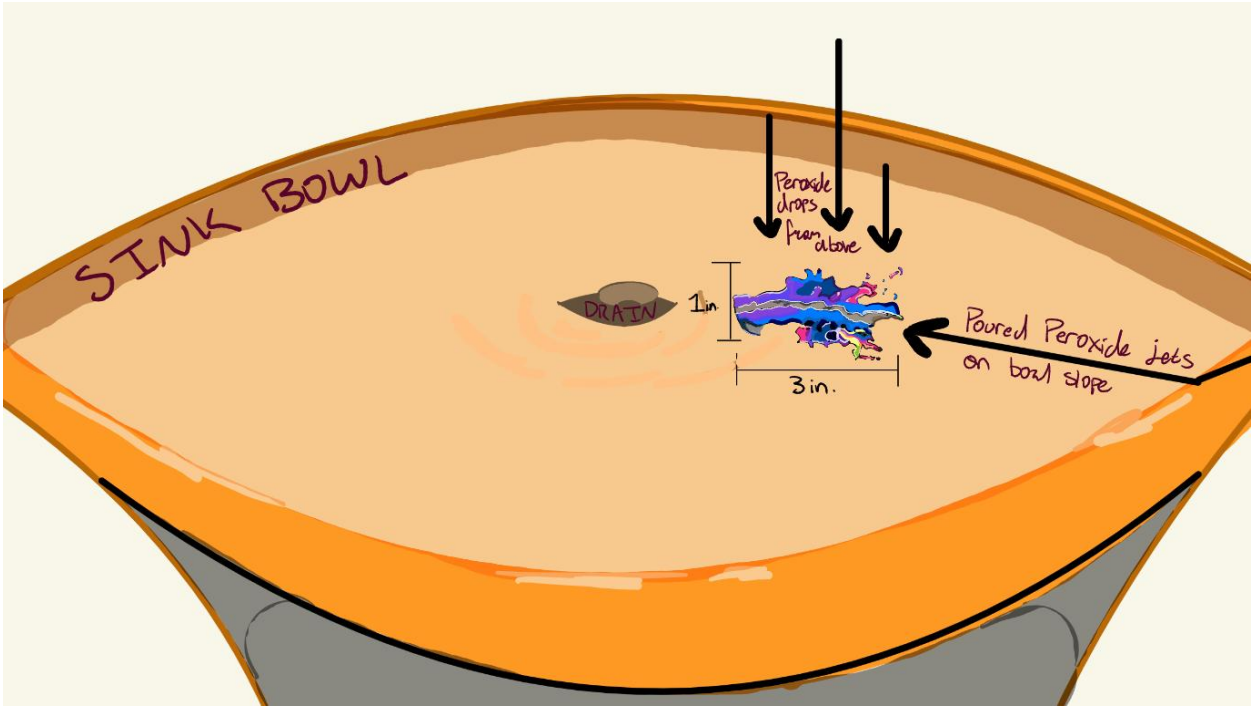


Figure 3

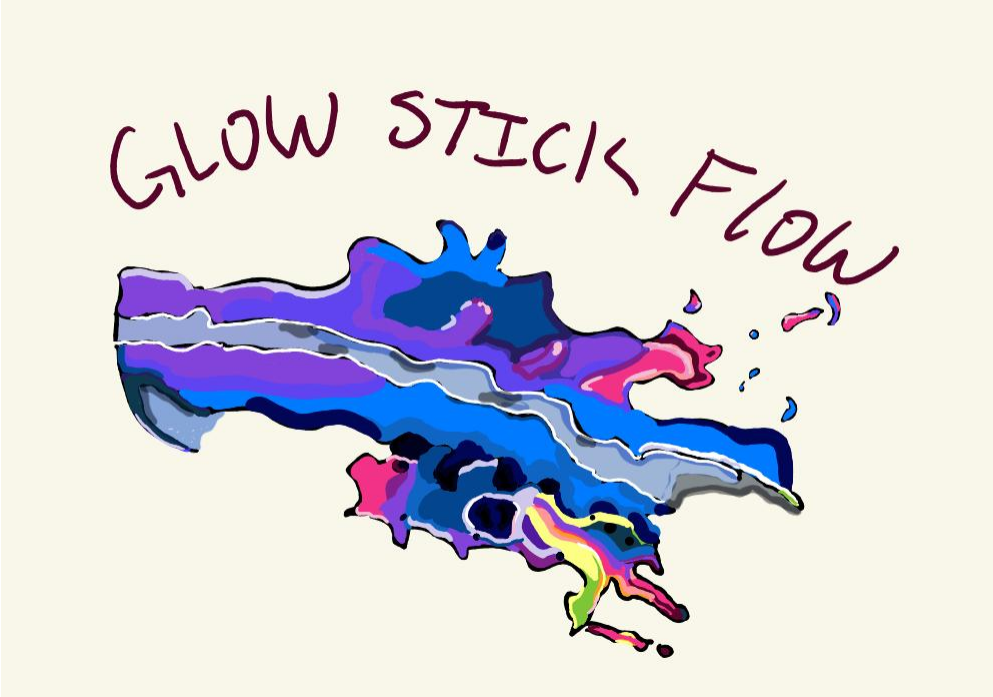


Figure 4

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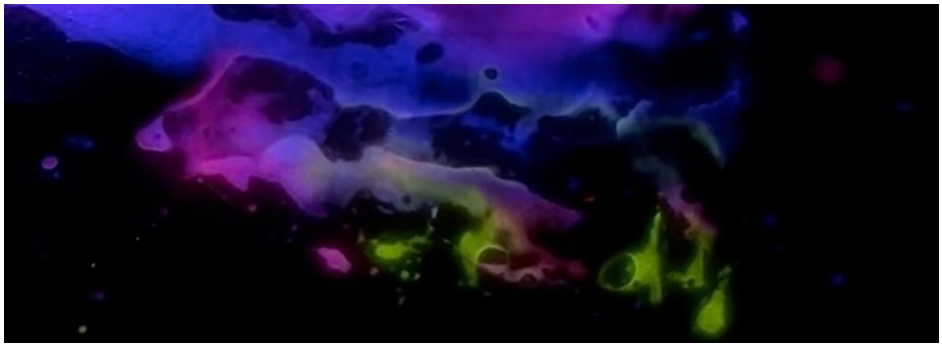


Figure 5

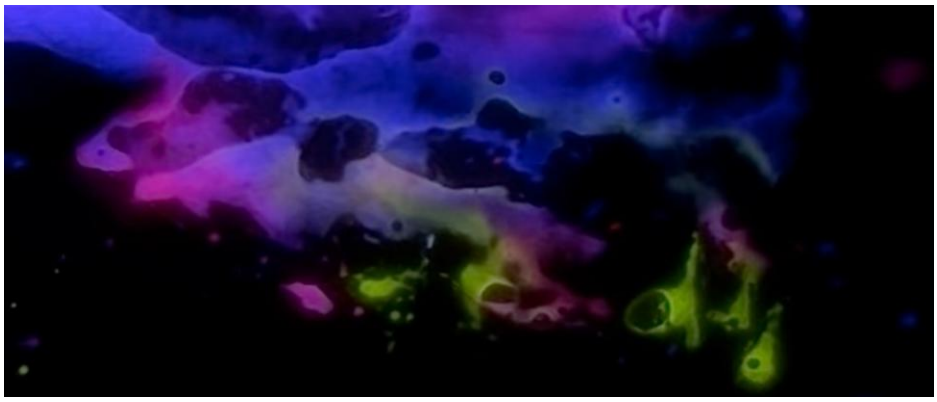


Figure 6

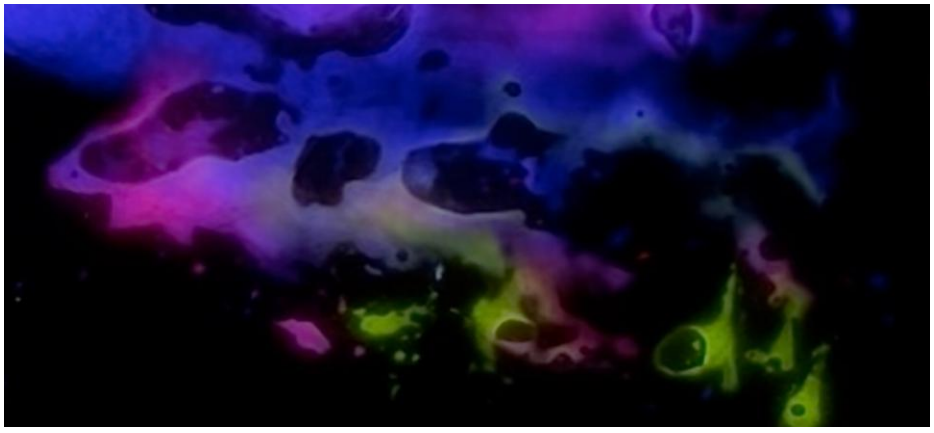


Figure 7

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Citations:

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