Team Third Report: Buoyant Teardrops

Xeen Meighan
FlowVis MCEN 5151

November 22, 2025

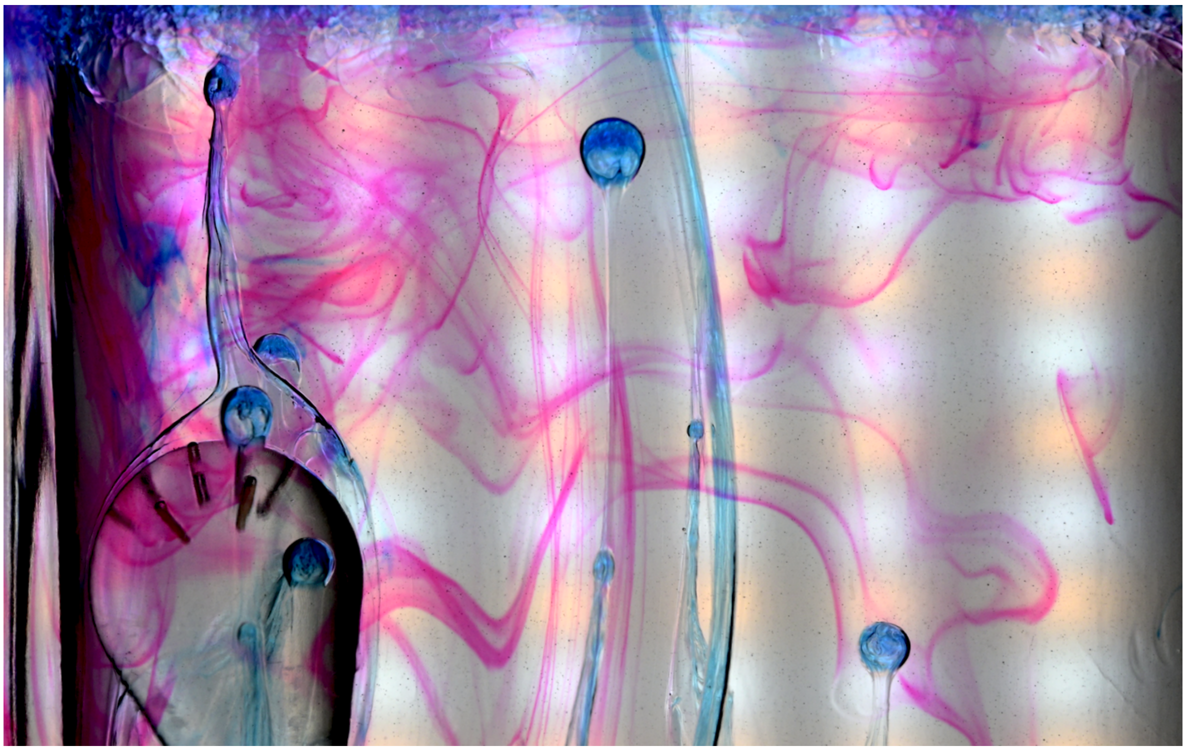

Figure 1: The final image 'Buoyant Teardrops'.

1 Introduction

For the Team Third project of Flow Vis my team wanted to explore how viscosity and buoyancy play together in driving and shaping flows. My team members for this project were of Luke Freyhof and Alana Martinez. Our original goal was to trace out the streamlines of objects as they fell through a viscous medium. This did not play out exactly as planned but we were able to get interesting images showing the flows caused by the disturbances of a layered density system we set up. Visually my goal for this image was to create an interesting and colorful image using fluids while not worrying too directly about being able to understand exactly whats going on in the flow at a first glance.

2 Flow Physics

The major physics dictating what we see in this situation is the balance between the viscosity and buoyancy between these fluids. We have three different fluids visible in this setup. The bulk is our clear glycerin-water mixture and in this bulk we have two colorful dyes. The pink is pure food dye that was applied to the surface of objects that we dropped into the bulk. The density seemed to be on the same order as the bulk because it was almost neutrally buoyant and remained floating in the bulk. The blue dye on the other hand was a mixture of water and blue food dye and was noticeably less dense than the bulk and wanted to remain on the surface. In figure 3 the first image shows the initial fall of the teardrop object dragging down some of the less dense blue dye while figure 2 shows a top down view of the setup where you can see the layer of blue food dye resting on top of the clear bulk.

The main physics of this image that I looked into was the shape that the blue dye takes as it floats backup through the bulk. The shape and motion of drops and bubbles moving though viscous and viscoelastic solutions has been studied before in fluid mechanics [1, 2]. In our image we can see multiple spherical drops with solid connected trails behind them. This behavior has been experimentally and mathematically seen and described in fluid papers [2]. We can calculate the Archimedes number, which describes the relation between buoyancy and viscosity and is given by $Ar = \frac{\Delta\rho g D^3}{\rho_f \nu^2}$ where for this system comes out to approximately 40. This tells us the buoyancy is prevalent in driving the flow motion but we still see a long continuous shear of the trail behind the drop. If the viscosity was dominating to a higher degree we would expect the trails behind these drops to shear into smaller drops rather than staying as one connected drop.

The spacial and temporal resolution of this image is pretty good compared to the speed of the fluid. The rise speed of the droplets was only 2.2 cm/s, so in this frame the fluid only moved 0.02 cm which is the same order of magnitude that our smallest resolvable object, meaning that there is no notable motion blur effect.

3 Visualization

Our setup for this experiment consisted of a small vase the we filled with a water-glycerin solution of a ratio of 450 ml glycerin and 50 ml of water. The pink dye shows the disturbances left in the bulk from dropping some of our 3D printed objects with the pink dye placed on the surface of the objects which where then dropped through the main medium. We then created a batch of blue dye with water and a small amount of glycerin. We then poured this on top of our clear glycerin, this solution remained on the surface because it was less dense than the bulk.

The setup was lit by two different LED panels. The first was from underneath under-lighting the vase and then other was placed behind and directly shined through the vase. Our camera was mounted on a tripod and was about 45 cm away from the system. Figure 2 shows the layout and components used in the setup.

4 Photo Details

The original video was taken on a Nikon Z6 with a Nikkor ZMC 105 mm lens. The video was taken at 120 fps and has resolution of 3840 x 2160 pixels. The camera was set with an aperture of f/5.6, iso 400, focal length of 105 mm and the focus distance was set at 0.39 m. The area captured has an area of about 10 x 7 cm. I cropped the final image down to 3436 x 2160 pixels.

The editing of this image included increasing the exposure of the image slightly and adjusting the RGB curve to increase the color contrast.

5 Reflection

In the end, this image was a fun expansion on some of the techniques we learned and experimented with through the semester and shows off the skills I was able to learn this semester when it comes to camera settings and creating experimental setups good for fluid photography. One improvement that could be made to this image would be to have a more solid background by diffusing the background LED. The background colors are very consistent so this could also be addressed through some careful editing. Even so I think this is a very fun final image.

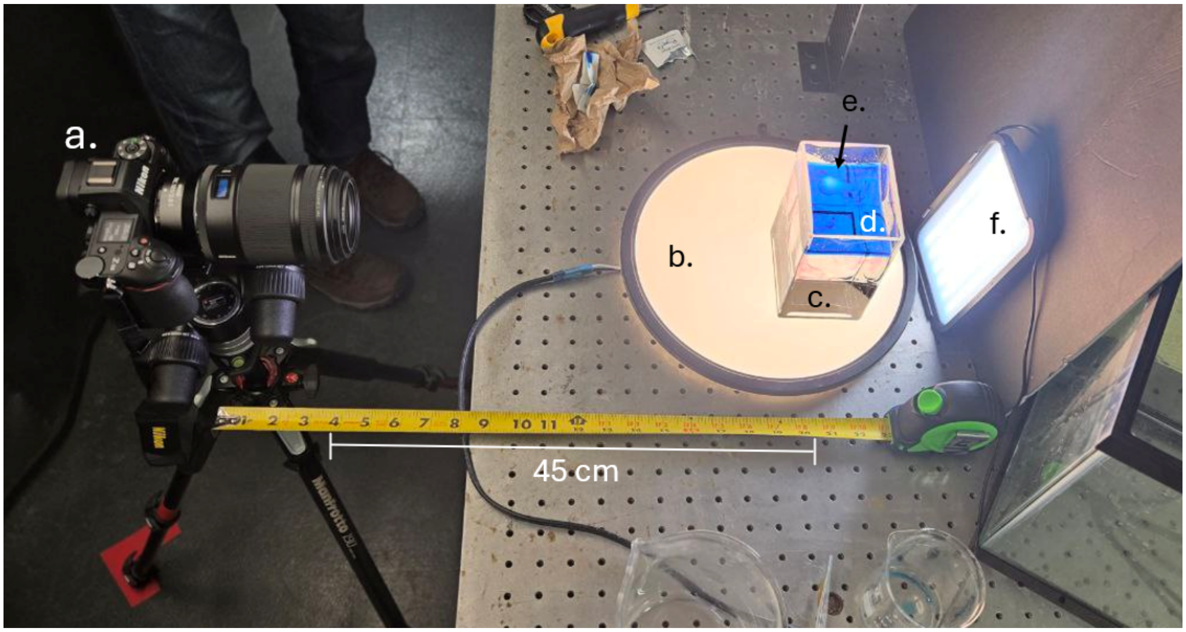

Figure 2: This image shows the setup used for this shot. The components that made up the experiment are: a. tripod mounted camera, b. under-lighting LED, c. clear glycerin bulk, d. blue-dye top layer, e. 3D printed teardrop, and f. back-lighting LED. The lens to focus plane distance is about 45 cm.

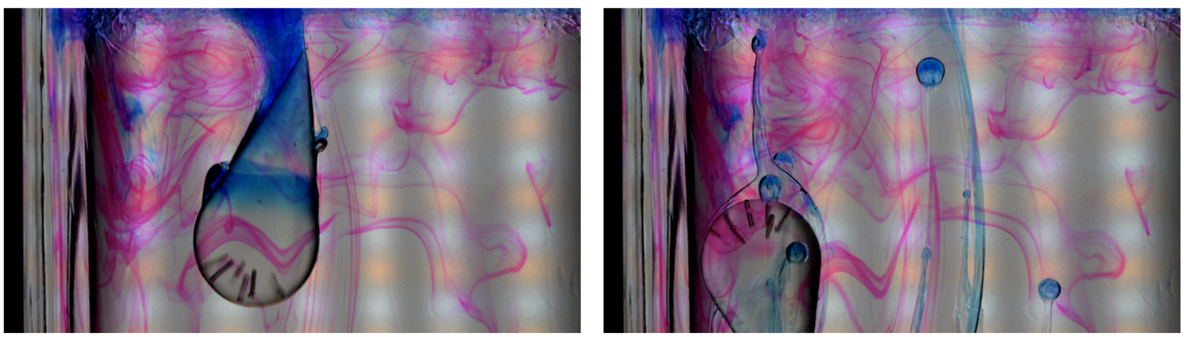

Figure 3: On the left is the fall of the teardrop 3D print through the glycerin dragging down some of blue dye that was on the top of the clear bulk. The right image shows the unedited original frame used for 'Buoyant Teardrops'.

References

[1] D. Bhaga and M. E. Weber. Bubbles in viscous liquids: Shapes, wakes and velocities. 105:61–85.

[2] G. Esposito, Y. Dimakopoulos, and J. Tsamopoulos. Buoyancy driven flow of a viscous drop in viscoelastic materials. 321:105124.