Team First Report: Cornstarch Trails

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FlowVis MCEN 5151

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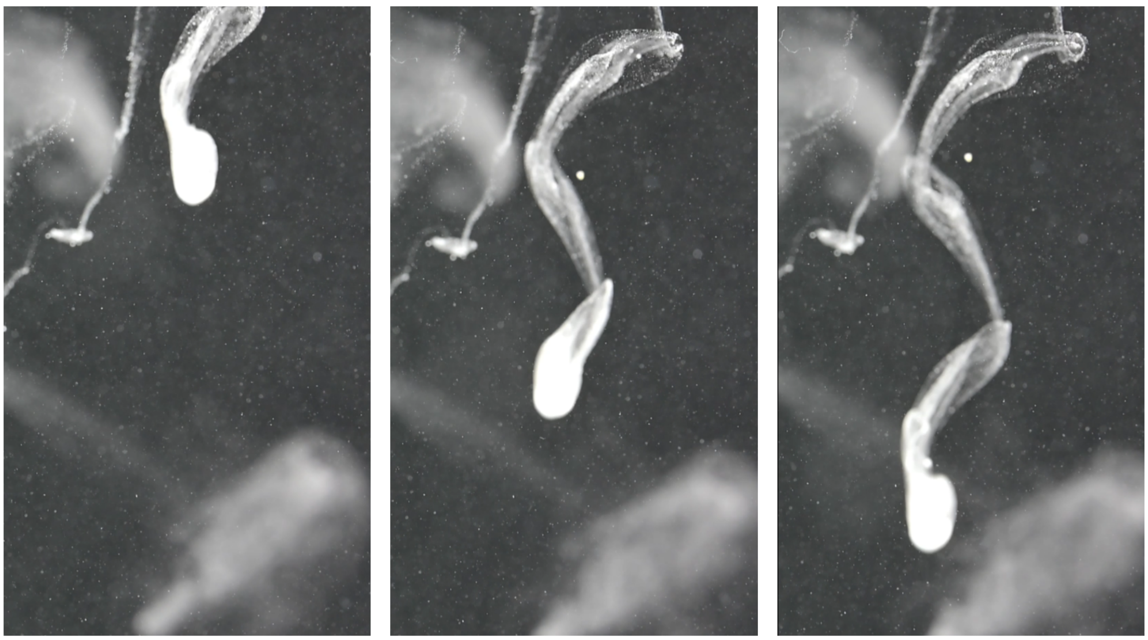

Figure 1: This series of images shows the initial fall of the drop of interest through the tank. The drop takes a wobbling path due to the uneven forces it experiences showing off a phenomenon known as vortex shedding. From left to right these stills were captured at times 1.70 s, 1.95 s and 2.11 s in the video.

1 Introduction

This video came about as a result of the Team First assignment of FlowVis. My team members for this project were of Luke Freyhof and Alana Martinez. With this video we were able to capture the effect of vortex shedding on one of the cornstarch drops falling through the tank. The video itself also came out very artistic because of the black and white color palate created by the white cornstarch and the black background. This contrast along side the beautiful spirals of the vortexes create a striking visual.

2 Flow Physics

The main flow effect shown in this video is vortex shedding. This is shown by the back and forth movement of the drop as it falls. At these turning points we get little spinning eddies or little vortex curls due to the overturning of the local fluids. Most of the research into these structures use a solid body and put it in a flow [2]. This allows the researches to tune the parameters of the flow to play with

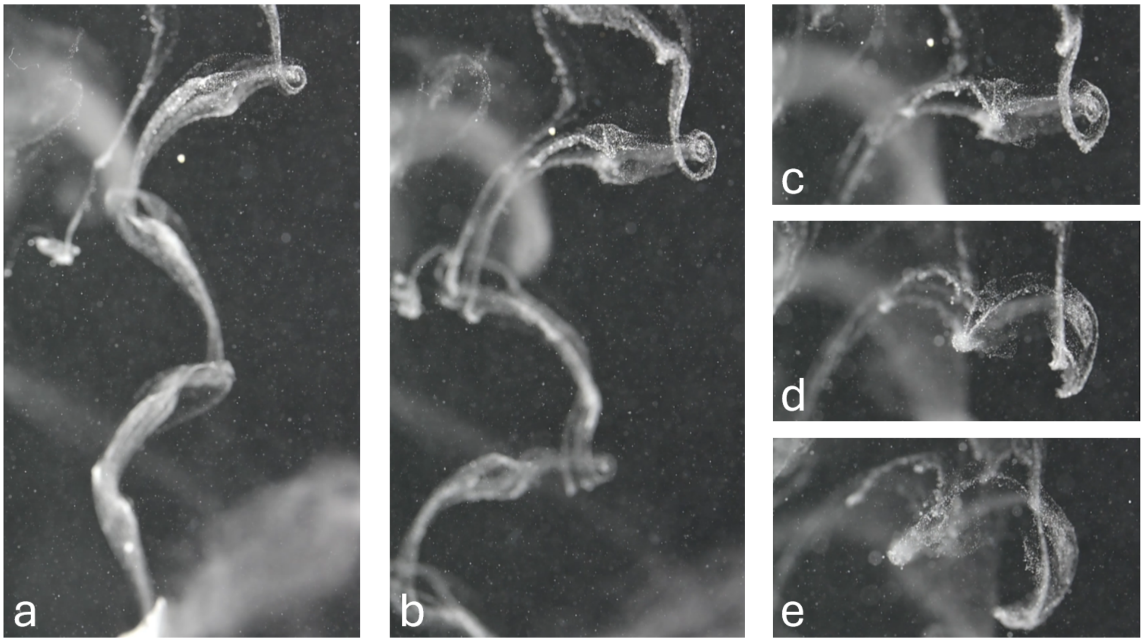

Figure 2: This series of images show the later evolution of the trail structure after the drop has left the frame. Images a and b show the full frame and trail while c,d and e are closeups of the upper vortex structure changing with time. In c we see the clean structure of the spiral while in d and e it starts to dissipate. The times corresponding to the snapshots a to e are 2.25, 3.31, 3.37, 4.77 and 6.07 seconds.

different Reynolds numbers. The Reynolds number is a key way to quantify the expected behavior with this phenomenon. It shows the relation between the inertia and viscosity in the system. Doing an estimate of the Reynolds number gives us:

$$Re = \frac{\rho v L}{\mu} = \frac{1200kg/m^3 * 0.2m/s * 0.02m}{1 * 10^{-}3Pa * s} \approx 2400$$

This puts us in the mid-low range of Reynolds numbers. This means we expect some periodic vortex shedding but it is not expected to be uniform. We can still draw parallels to the von Kármán vortex street effect which is when we have vortex shedding at regular frequencies [1]. We can compute an estimate of the Strouhal number to look at this relation.

$$St = \frac{fL}{U} = \frac{5hz * 0.01m}{.2m/s} = 0.25$$

This estimate matches what is typical of bluff bodies where this effect is seen[2].

3 Visualization

This phenomenon was able to be captured in this manner because the cornstarch droplets would leave smaller particles behind as they fell creating their own set of tracers that then show off the flow of the water behind the drop. We had also done a couple previous attempts with cornstarch in this tank which we did not clean it out before this shot. As a result the tank was already seeded with lots of small cornstarch particle suspensions. These particles are similar to the ones coming off the falling drops and are close to neutrally buoyant. This seeding of the general bulk show the relative stillness of the water outside of these drop trails.

The setup for this experiment consisted of a small rectangular fishtank that was lit by two 10 watt, 8 inch LED panels from the brand Ubeesize. One of these lights were positioned on either side of the tank as shown in figure 3. The cornstarch was a generic consumer brand that came in a fine powder. For the video, Luke was able to sprinkle a couple tablespoons of cornstarch on the top of the tank by tapping the starch out of a smaller container. The cornstarch was at first hydrophobic and stayed on the surface of the tank but after a few seconds clumps of cornstarch started to fall down tracing out its path with cornstarch particles that leave the main clump as it falls.

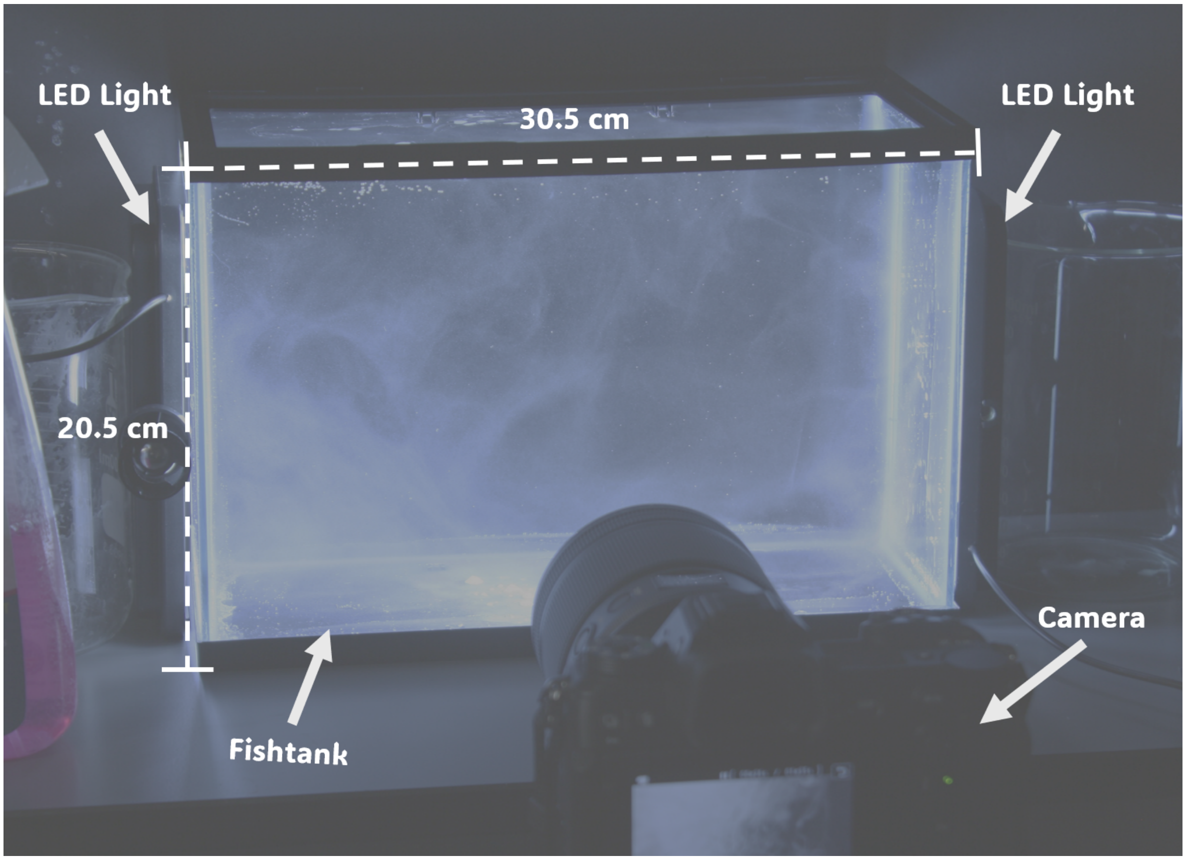

Figure 3: This image shows the setup used to capture "Cornstarch Trails". It shows the camera setup on a tripod directed toward the fishtank. There are 2 LED lights that are setup on apposing sides of the tank shinning light from the sides. There is also a black posterboard behind the fish-tank creating the black background. Credit to Alana Martinez for this image of the setup.

4 Photo Details

This video was taken on a Nikon Z6 with a Nikkor ZMC 105 mm lens. It was shot at 240 fps and originally exported at 1920 × 1080 pixels. I cropped the video to focus on one of the vertical sections; leaving the video at 1080 × 1920 pixels. The video was then also exported to 30 fps. The camera was set with an aperture of f/3.3, iso 1600, focal length of 105 mm and the focus distance was set at 0.39 m. The area captured is about 7 x 14 cm in the final cropping. I did not add any extra post processing to the coloring or contrast of the video.

5 Reflection

From this assignment I was able to create an interesting visual showing off the ordered chaos of some free-fall motion. I like how this this technique was able to show the local behavior of the fluid after a disruption and then how it starts to recover with time as the source no longer influences the behavior. The cornstarch particles in the bulk of the tank had a good distribution where they allowed you to see bulk behavior without obscuring the more dense region that came from the droplet. An extension and improvement that could be made is in the experiment procedure. The original set up captured a larger field of view with the chaos of many different drops falling through the water. Allowing for more individual shots of these drops would allow for a more distinct shot and stills. Another addition to this video that would improve the quality is to find music that would help compliment the visual.

References

[1] P. W. Bearman. On vortex street wakes. 28(4):625–641.

[2] Masaru Kiya, Hisataka Tamura, and Mikio Arie. Vortex shedding from a circular cylinder in moderate-Reynolds-number shear flow. 101(4):721–735.