MCEN 4151: Vis 2 Report

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1 Introduction

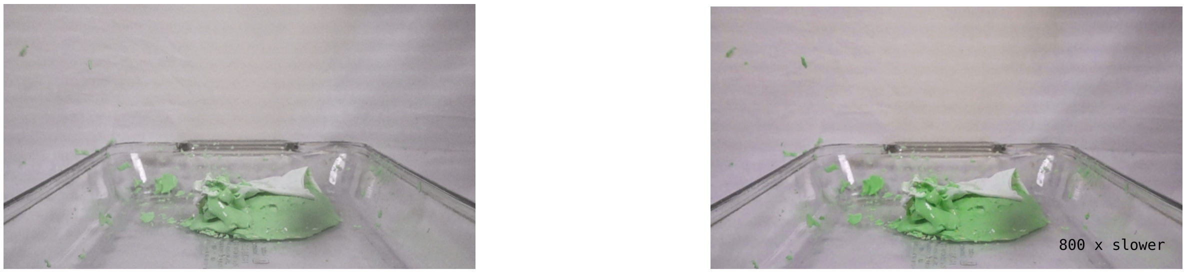
For the second project, my intent was to capture non newtonian fluid mechanics of oobleck using a high speed camera. After some experimenting, I settled on putting oobleck inside a balloon and popping it. I thought this was unique and would result in really interesting high speed footage as this was a fast process not easily observed with the naked eye. I used green dye arbitrarily but, with the benefit of hindsight, would've chosen a darker color (such as purple) to contrast with the light background. This project was assisted by Ryan Wells, who rented and operated the high speed camera, Maridith Stading, who helped stuff the balloons, and Kelsie Kerr, who rented the lighting equipment.

2 Setup and Procedure

The apparatus setup was straightforward and similar to my first project. A pyrex oblong baking dish was placed on a table against a wall. A white bed sheet was draped over the table and extended up the wall behind it. This was secured in place using generic duct tape. The camera (Sony NEX-FS700U) was positioned a little under a foot away from the subject and placed on a tripod. The tripod was adjusted so the camera was at the same height as a white 12" Spritz balloon that was held approximately 6 inches above the dish. Three IFB576 lights were placed at varying angles, oriented so the majority of the light was directed directly at the balloon. These were elevated to roughly a foot above the balloon height and were angled down slightly. Brightness was at 100% and the color temperature was set to 5600 K (coolest setting). A picture of the setup is shown below in Figure 1.

The oobleck was mixed in a mixing bowl at room temperature with an approximate ratio of 2 cornstarch to 1 water. Some cornstarch was added until the consistency was thick enough that it would only run slowly. Next, the balloon was blown up by mouth to about the designed diameter of 12" and left to stretch for 20 minutes. The balloon was then allowed to deflate before being stuffed with oobleck. One person held the neck of the balloon open while the other used a spoon to scoop and shove oobleck into the balloon until the amount leaking out the top was about the same as the

Figure 1: Light and Camera Placement of Project 1. See above for key differences for Project 2



(a) Screenshot of Unedited Frame (b) Frame After Saturation Adjustment

Figure 2: Before and After Saturation Edits

amount be added. The balloon was then once again blown up by mouth to the same size as before, leaving it partially filled with oobleck. A sharpie was then used to draw the smiley face to give the balloon a depth marker.

For trial one, the balloon was held with the opening up and then poked with a needle to cause it to pop. For trial two, the balloon was inverted for about 30 seconds before the shot was taken to allow oobleck to flow up the walls. It was then righted and quickly popped within 10 seconds of righting.

3 Relevant Physics

Oobleck is a non newtonian fluid. More specifically, oobleck is a shear thickening, or dilatant fluid because its apparent viscosity increases with increased shear stress [**1**]. In other words, oobleck acts more like a solid when a force is applied, but flows like a liquid when there are small or no shear stresses in the fluid. We can see some effects of this in the two trials captured. When there is an impact or force applied to the oobleck, it acts like a solid, not dissipating energy outwards with ripples and wavelike behavior, but maintaining its shape [**2**].

In the first capture the oobleck remains in its shape after the balloon is popped, a result of the forces the balloon was enacting on the oobleck before. Then, the very edge (nearest to the camera) begins to start flowing away from the rest of the disc of oobleck. This edge holds shape during the impact of the disc on the dish due to the shear forces involved. After the force dissipates some, the edge can then be seen freely flowing away. In the second capture, the oobleck acts like solid pellets when the balloon initially pops. Some of the larger pieces of oobleck that impact the dish bounce or stick like a solid at first, but then visibly soften and flatten shortly thereafter. Also, the oobleck seemed to initially spatter to the right, before a larger volume then spattered to the left with respect to the camera. I believe this to be a result of the direction the balloon ripped in. The shear forces caused the oobleck to accelerate along with the balloon material it was in contact with, propelling it in that direction when the two eventually separate.

4 Photographic Technique and Choices

The field of view of the video is approximately 2.5 feet by 1.5 feet. This allowed the balloon to mostly fill the image while still allowing for the peripheral oobleck spatter to be captured. The balloon was approximately 10 inches from the lens of the camera. Most of the settings on the camera were automatic, meant to cater to the frame rate setting of 6000 fps.

Blender was used to edit the video. The saturation of all clips was set to 1.5 because the color looked somewhat flat otherwise. A comparison of this is shown in Figure 2. I chose to include both captured trials in the video as I felt both demonstrated different qualities of the oobleck. I also further slowed these clips down so that more of the concurrent action of different pieces of oobleck could be observed more easily. In addition to adding a title and credits, I also felt it prudent to add a timescale in the video to give the viewer a sense of how quickly this happened. Lastly, I utilized royalty free music (”Deep in the Ocean” by SergePavkinMusic) as I felt this matched the sense of slowness and beauty I thought my video had.

5 Further Work

The video really shows the two different states of the oobleck and I felt was quite fun to capture and view. It gives the subject a sense of weightlessness as the pellets of oobleck lazily go about their trajectory before oozing outwards some time after impact. If I were to replicate this experiment in the future, I would be interested to see the effect of darkening the hue of the oobleck as I feel this would make the fluid pop more against the light background. I would also consider trying to find a way to add a higher volume of oobleck to the balloon, perhaps in the way of stretching the balloon for longer. Lastly, I would like to try coating the balloon more completely before popping. This would create more of a mess, but it may add to the slow chaos that ensues afterwards.

References

[1] Steele, Bill. “The Secret of Oobleck Revealed at Last.” Cornell Chronicle, Cornell University, 24 Nov. 2015, https://news.cornell.edu/stories/2015/11/secret-oobleck-revealed-last.

[2] V. Siva Rama Krishna, et al. ”Experimental evaluation of impact energy on oobleck material (non-Newtonian fluid).” Materials Today: Proceedings, vol. 45, Part 2, 2021, pp. 3609-3617, https://doi.org/10.1016/j.matpr.2020.12.1112.