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Team Second Report

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Oobleck Reaching Down

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1 Introduction

For our second team assignment, Anton, Jay, and I decided to experiment with the non-Newtonian fluid "oobleck" to visualize the unique flow characteristics associated with shear-thickening. Oobleck does not have a constant viscosity, but responds differently depending on how quickly force is applied. We were interested in how this behavior could be represented visually and used multiple techniques. I chose to go with oobleck flow through a colander.

Figure 2 captures the oobleck as it exits the colander and forms long, thin strands with rounded bulbs on the end. The intent was to visualize the forces on oobleck that makes non-Newtonian fluids so interesting and capture them in an artistic way.

2 Experimental Setup

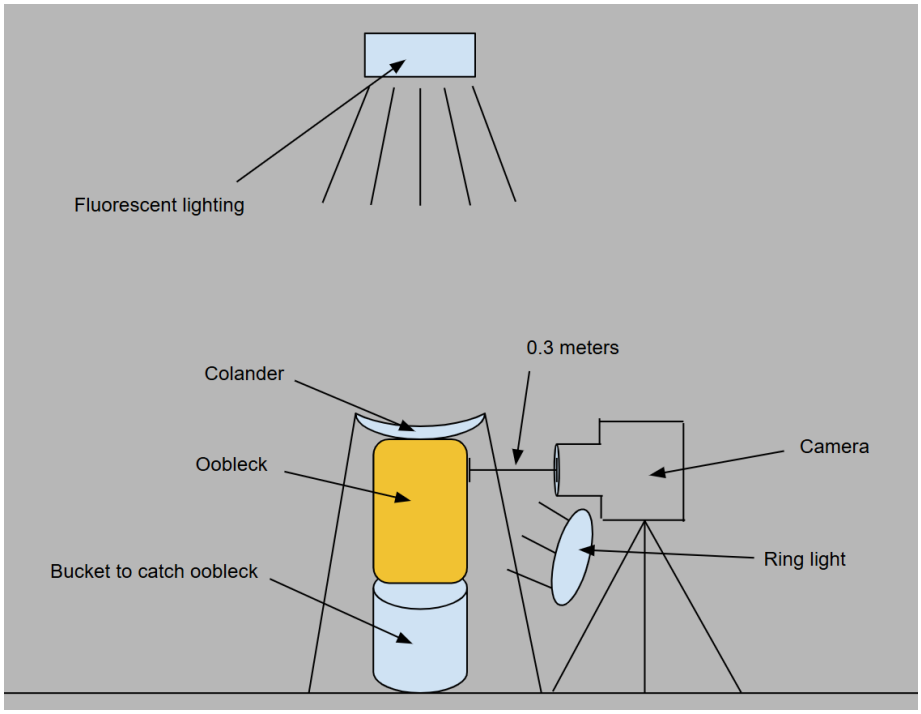


Figure 1: Experimental setup for the flow of oobleck through a colander.

The team prepared a mixture of 2 parts cornstarch and 1 part water to create the oobleck. We made the mixture in a bowl and poured the mixture inside a colander containing multiple equidistant half-inch holes. There was a bucket beneath the colander to collect the oobleck that fell. Looking to Figure 1, the camera was positioned approximately 0.3 meters from the fluid; fluorescent lighting came from ceiling lights and LED lighting was provided by a ring light.

3 Flow Physics



Figure 2: Unedited experimental visualization.



Figure 3: Post-processed experimental visualization.

The inertial and gravitational forces work together to pull the fluid downward. As it leaves the colander, the fluid is no longer trapped by the walls of the holes and begins forming individual strands. The non-Newtonian behavior of oobleck comes from its high concentration of suspended cornstarch particles. As the deformation rate increases, interactions between the particles can increase the resistance to flow. Brown and Jaeger (2009) showed that the magnitude of shear thickening in dense suspensions depends strongly on the particle concentration, with sufficiently concentrated systems approaching a "jammed state". This is why oobleck can behave like a solid when a quick, impactful force is applied.

An interesting phenomenon is the formation of rounded bulges at the end of the oobleck strands. Gravity pulls the suspending fluid downward, stretching the material as it exits the colander. At the same time, surface tension reduces the surface area of the fluid and forms the rounded shapes. As the strands stretch, the local deformation rate will change and therefore change the viscosity. All together, the interaction between gravity, capillary forces, and the changing viscous behaviour of the oobleck all contriute to the complex structures visible in Figures 2 and 3.

Similar structures were examined by Zimoch et al. (2013). It was demonstrated that beads-on-a-string formations can develop during the breakup of discontinuously shear-thickening suspensions. Their study showed the influence of rate-dependent rheology on how fluid filaments thin and break apart. The stretching behavior of oobleck has also been examined by Bischoff White

et al. (2010), who investigated the extensional viscosity of cornstarch and water suspensions. Extensional viscosity characterizes the resistance of a fluid to being stretched. Their study found that as the extension rate increases, the fluid can experience strain hardening, increasing its resistance to further deformation. The rounded ends of the strands in Figures 2 and 3 may therefore be influenced not only by surface tension, but also by the extensional rheology of the suspension.

The Bond number shows the relationship between gravitational and surface tension effects:

$$Bo = \frac{\Delta\rho g L^2}{\sigma}, \tag{1}$$

where $\Delta\rho$ is the density difference between the oobleck and the surrounding air, g is gravitational acceleration, L is the characteristic length and σ is the surface tension. Taking the density difference to be approximately equal to the density of oobleck (since air density is negligible in comparison) and assuming water-like surface tension:

$$\Delta\rho \approx 1300\,\mathrm{kg\,m^{-3}},\ g\ = 9.81\,\mathrm{m\,s^{-2}},\ L = 0.005\,\mathrm{m},\ \sigma\ = 0.070\,\mathrm{N\,m^{-1}} \tag{2}$$

Substituting into Equation 1:

$$Bo = \frac{(1300)(9.81)(0.005)^2}{0.070} = \boxed{4.6} \tag{3}$$

The estimated Bond number is greater than 1, indicating that gravity is larger relative to surface tension at the chosen diameter for the oobleck strand. This result is consistent with the downward stretching seen in Figures 2 and 3. Since the Bond number depends on the square of the characteristic diameter, smaller/bigger strands experience a different ratio between gravity and surface tension. This may be one reason why some strands are thin while others develop rounded bulges.

4 Visualization Technique and Equipment

The team used a colander, 2 parts cornstarch/1 part water, a bowl, and a bucket to produce the flow. The colander was held up by two chairs on the edges, as opposed to someone holding it and creating unecessary motion. We used a green dye for the oobleck, with the original color shown in Anton's photo. The setup was illuminated using bright fluorescent lighting from the ceiling of a classroom about 3 meters high, as well as a 10 watt (5V, 2000 mA) LED ring light with a 0.254 meter diameter held just below the camera. This allowed light to reflect off the surfaces of the strands. A dark felt was used as background, which was important for creating contrast between the flow and its surroundings. This also allowed for smaller variations in strand diameter to become more visible in the final image.

5 Photographic Technique

Figure 2 was captured using a Sony ILCE-6300 mirrorless camera with a focal length of 50 mm. The camera was placed about 0.3 meters away from the flow, giving a field of view of 14.3 cm × 9.51 cm. The original image was 4240 x 2832 pixels, which gives a spatial resolution of approximately 0.14 mm per pixel, resolving fluid's texture. The aperture was set to f/5.6, the shutter speed was 1/320 sec, and the ISO was 640. These settings were chosen to avoid blur, attempting to resolve the flow in time and space as best as possible.

The original image was edited in darktable to enhance both the artistic and physical effects of the flow. The exposure was increased to +1.109 EV, with a small increase in black level correction to maintain the dark background. The increase in exposure helped brighten the photo. To get the yellow color, I maximized the blue-yellow contrast option. I cropped the photo on the left, right, and top to highlight the strands of oobleck, while removing unnecessary dark space and keeping a small portion of the colander at the top for image context.

6 Conclusion

This image reveals the physical phenomena of a non-newtonian fluid flow, with long strands of yellow oobleck contrasting with a dark black background. I enjoy looking at the differences between the strands, both in thickness and length. The slight bend in some of the strands shows the effects of the inertial forces on the oobleck caused by pouring the fluid. If I were to do it again, I would try different sized holes to create more disparity and contrast. One discovery is that trying to capture the physics of oobleck in a photo in hard, so a video would be a great alternative. Overall, I am incredibly happy with how I was able to represent this flow, where I highlight an artistic expression of contrasting elements to create a flow appearing to reach down.

References

1. Bischoff White, E. E., Chellamuthu, M., and Rothstein, J. P. "Extensional Rheology of a Shear-Thickening Cornstarch and Water Suspension." *Rheologica Acta*, Vol. 49, pp. 119–129, 2010. https://link.springer.com/article/10.1007/s00397-009-0415-3.

2. Brown, E., and Jaeger, H. M. "Dynamic Jamming Point for Shear Thickening Suspensions." *Physical Review Letters*, Vol. 103, 086001, 2009. https://arxiv.org/pdf/0904.0671.

3. Wikipedia Contributors. "Eötvös Number." *Wikipedia, The Free Encyclopedia, Wikimedia Foundation.* https://en.wikipedia.org/wiki/E%C3%B6tv%C3%B6s_number.

4. Zimoch, P. J., McKinley, G. H., and Hosoi, A. E. "Capillary Breakup of Discontinuously Rate Thickening Suspensions." *Physical Review Letters*, Vol. 111, 036001, 2013. https://web.mit.edu/nnf/publications/GHM200.pdf.