Team First - Fall 2025

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Purpose and Context

The objective of this image was to capture the wake that forms once a substance falls through water. The original intent of this image was to capture the wake that forms behind an object pulled across the surface of water. As the experiment progressed, however, we found that the setup to which we had access was much too small to accurately produce this phenomenon. The redirection allowed us to play with the idea of an object falling through water to observe the turbulent wake that occurs. I would like to thank both Luke Freyhof and Xeen Meighan for their assistance in capturing this image!

Materials and Methods

The initial setup for this experiment was relatively simple, consisting of a camera, a tripod, a 5-gallon fish tank, a ruler, a black canvas in the background, and some cornstarch. Provided below is a sketch of the apparatus that was used to capture this flow phenomena, from both the camera's perspective and the perspective of a viewer looking down on the setup.

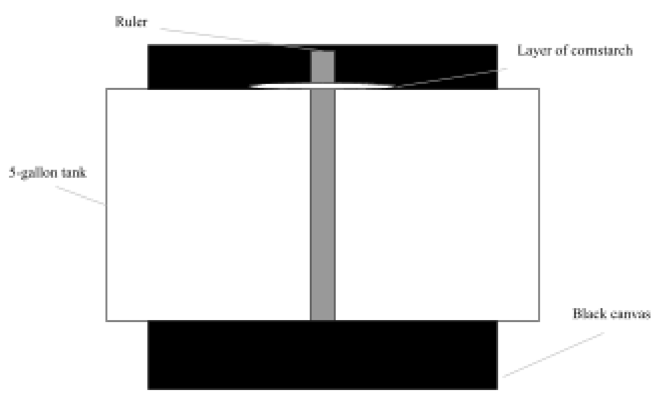
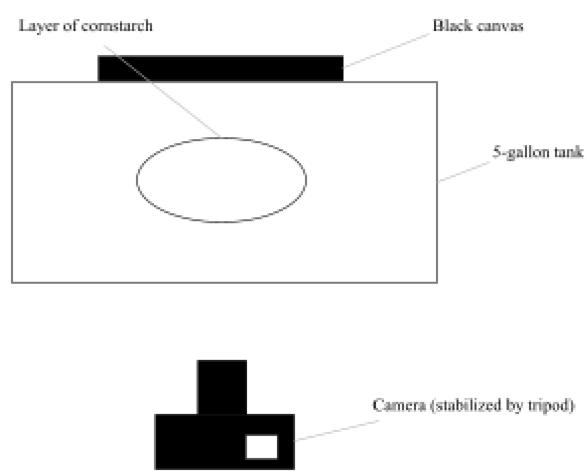
<table>
<tr><td>
</td><td>Camera POV</td></tr>
<tr><td>
</td><td>Top-down POV</td></tr>
</table>

Figure 1: Experiment setup

Once the camera was secured to the tripod, it was moved to about 3 inches away from the glass tank. Taking into consideration the fact that the cornstarch was released near the center of the tank (16x8x10 inches), we can assume that the lens was approximately 7 inches away from the cornstarch at the moment the photo was taken. There were two 1800-lumen, USB-powered led panel lights that were utilized to get proper lighting. Each one was placed on either side of the tank, providing enough light to highlight the cornstarch as it fell through the water. To aid in this process and after some failed attempts at trying to capture the white cornstarch as it fell, the team decided to place a black canvas behind the tank to allow for the contrast to be seen more clearly. We also decided to use a ruler to help the camera focus on the water inside the tank rather than the air bubbles that were forming on the inside surface of the glass.

Fluid Dynamics

The main physics that are at play within this experiment are a result of 3 key factors: the suspension of cornstarch at the surface of the water, dispersed powered falling into slurry trails within the tank, and the turbulent flow that was captured as a result of the two mediums coming into contact with each other. To begin, the starch (when initially poured into the tank) formed a clump near the surface of the water. Unless you have boiling water to dissolve the molecules of the cornstarch, these bonds will not break within the water. Instead, you will have tiny particles of cornstarch that will be suspended in the water, eventually settling at the bottom of the tank [3]. This results in a very fascinating effect where you can track individual "particles" of cornstarch as they float down to the bottom, almost as if you were watching a particle from a Lagrangian standpoint. However, the photo I took for this scenario represents more of an Eulerian point of view to show the entirety of the fluid process rather than focusing on one portion of the flow [2]. On top of this suspended flow of the particles, we can observe several slurry trails that sink down, creating an interesting flow effect. When the particles are relatively fine, similar to what was observed in this case, it is assumed that "particle sizes from 40 µm to 0.15 mm [provide that] suspensions are maintained by turbulence" [4]. That is why, for this specific slurry, we can utilize Reynolds number to prove this theory. The equation for Reynolds number is shown below:

$$Re = \frac{\rho v L}{\mu}$$

If we take the length of a cornstarch clump to be 0.15mm (assumption based on ruler that was used in tank), the fluid density of the water to be 997 $\frac{kg}{m^3}$, the velocity of the cornstarch (untouched by other forces) to be around 30 $\frac{mm}{s}$, and the viscosity of the water to be 0.001*10^-6 $\frac{kg}{ms}$), we can calculate the following Reynolds number:

$$Re = \frac{\rho v L}{\mu} = \frac{(997\,\frac{kg}{m^3}) * (0.03\,\frac{m}{s}) * (0.15 * 10^{-3} m)}{1 * 10^{-6}\,\frac{kg}{ms}} = 4486.5$$

This high Reynolds number indeed proves that this flow is likely turbulent, shown by the various plumes that are present on the side of the flow.

Visualization Techniques

The final image was captured on a Canon EOS Rebel XS with an 18-55mm lens. The following table presents the exact properties of the final image.

Camera Settings	Value of Settings
Focal length	50 mm
Aperture	f/16
Shutter Speed	1/60 s
ISO	800
Size	1771 x 2592 pixels

Figure 2: Image Properties

As stated previously, the lens was about 7 inches from the location of the flow. Given that the focal length was 50 mm, the field of view for this image turned out to be 5.04 inches in width and 3.36 inches in height.

The lighting that was chosen was relatively low, so an increase in the ISO provided the additional needed lighting to capture such a contrasting phenomenon. While the shutter speed is relatively low for such a fast moving flow, I actually appreciated the blurriness as I felt that it truly focused on the turbulent flow that was occurring the rest of the image.

Some post-processing was completed for this image, including cropping the image to a more suitable size and adjusting the shadows and highlights via the RGB curve in Darktable. The two images below show the before and after of what post-processing was done. The original image was very over-exposed, so I tried my best to bring out the blues of the water and limit the bright white color that was present in the photo.

Original Image	**Final Image**

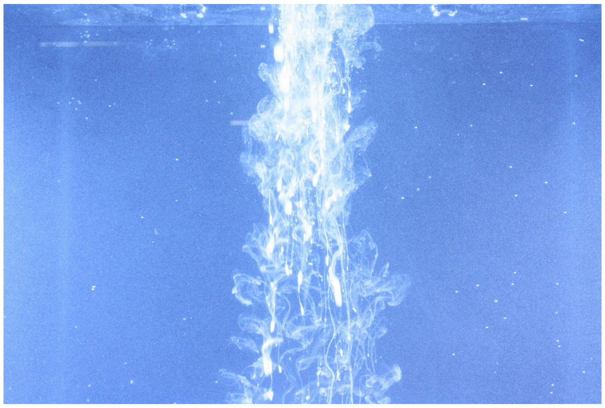
	
3888×2592 pixels	1771 x 2592 pixels

Figure 3: Original and Edited images

Conclusion

The final image captured shows the beautiful effect of how wakes form as objects fall through water. The lack of solubility of the cornstarch provided some beautiful slurry flow, resulting in crazy turbulence and "jellyfish-like" tendrils that swirl toward the bottom of the tank. I think this image beautifully displays the effect that simple density differences have on ordinary flow. If I were to recreate this image, I would try to lower my initial shutter speed to capture a frozen point in time to really highlight the fluid process. I would also like to experiment with different camera settings to obtain a less exposed image from the get go to perhaps enhance the fluid phenomenon that is observed. Overall, I believe this image displays the intended phenomenon from a different perspective than was initially decided upon, resulting in an interesting representation of turbulent flow.

References

[1] Czernia, Dominik. "Reynolds Number Calculator." *Omni Calculator*, Omni Calculator, 18 Mar. 2024, www.omnicalculator.com/physics/reynolds-number.

[2] De Padova, Diana, et al. "Comparison between the lagrangian and Eulerian approach for simulating regular and solitary waves propagation, breaking and run-up." *Applied Sciences*, vol. 11, no. 20, 11 Oct. 2021, p. 9421, https://doi.org/10.3390/app11209421.

[3] "Reynolds Number." *NASA*, NASA, www.grc.nasa.gov/www/k-12/airplane/reynolds.html. Accessed 28 Sept. 2025.

[4] Silva, Rui C. "Experimental characterization techniques for solid-liquid slurry flows in pipelines: A Review." *Processes*, vol. 10, no. 3, 18 Mar. 2022, p. 597, https://doi.org/10.3390/pr10030597.

[5] "Www.Scantips.Com." *Camera Field of View Details and Calculator (FoV)*, www.scantips.com/lights/fieldofview.html#top2. Accessed 28 Sept. 2025.

[6] Yousif, E.I., et al. "Physico-chemical and rheological properties of modified corn starches and its effect on Noodle Quality." *Annals of Agricultural Sciences*, vol. 57, no. 1, June 2012, pp. 19–27, https://doi.org/10.1016/j.aoas.2012.03.008.