Get Wet Report

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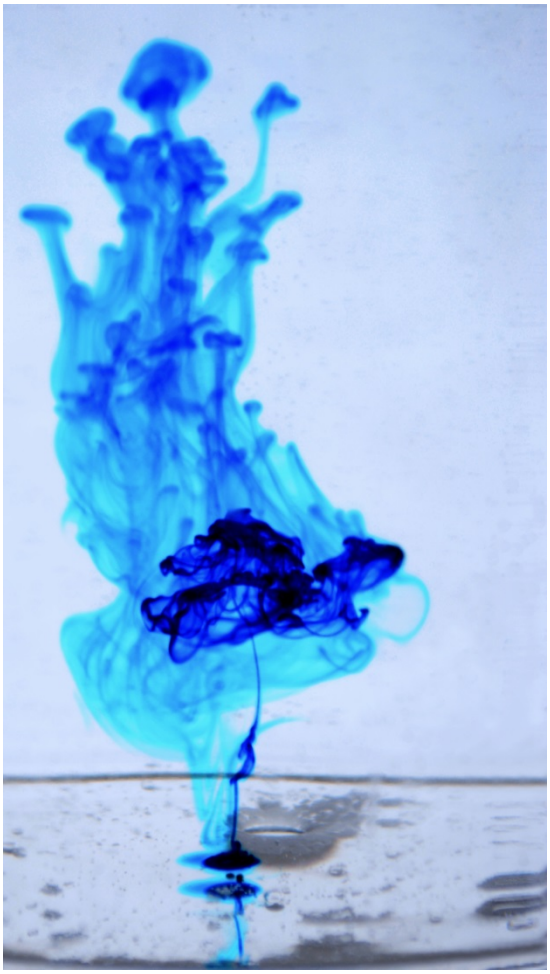
Flow Visualization: The Physics and Art of Fluid Flow



In this image, the effect known online to be “fireworks in a jar” was recreated. When oil sits on top of water and food coloring is dropped on the surface of the oil, the food coloring sinks to the bottom and pools, pushing through the very bottom of the oil layer. Once it has broken through the oil, it streams down into the water, creating a visual that resembles a firework, hence, “fireworks in a jar.” [1]

The basic setup behind the creation of this image is as follows: a rectangular, transparent container was filled with warm water. Coconut oil was then added to the water, melting into its liquid state and floating on top of the water. It is essential that the water is warm (above 76°F), or the coconut will remain a solid and the fluid flow will not work. About an inch of a coconut oil layer was used for this image. Here is a breakdown of the experiment, as demonstrated in the diagram below:

(a) A single drop of blue food coloring was dropped on top of the coconut oil layer.

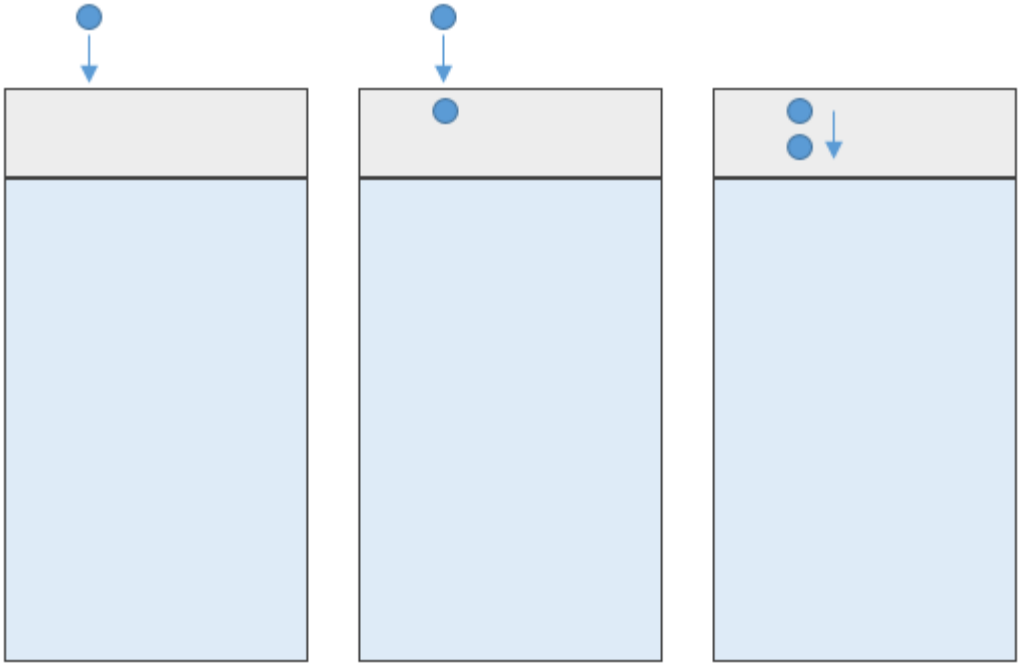
(b) Once that first drop has sunken about ¼” through the oil, a second drop is placed in the same position as the first, on top of the coconut oil layer.

(c) They both will sink at a slow pace through the oil.

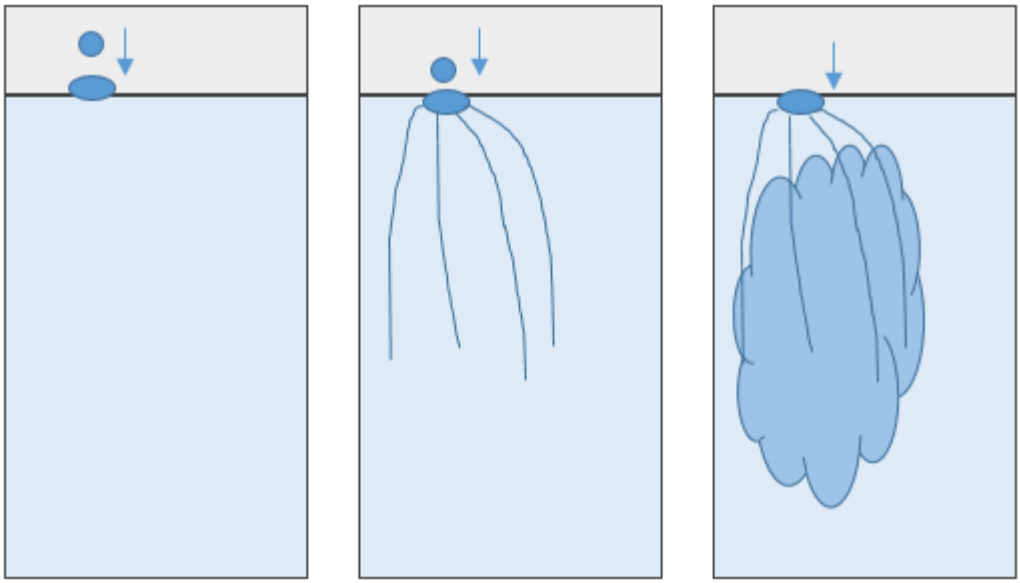
(d) Once the first drop reaches the bottom of the oil layer, it will begin to pool, trying to break out into the water.

(e) Once the first drop has breached that layer, the food coloring begins to stream down into the water. After the initial streams, the food coloring will disperse throughout the water, looking more like a cloud of color than a series of individual streams.

(f) The second drop follows exactly what the first drop did. It reaches the bottom of the layer of coconut oil and pools. Once it breaks out into the water, it begins to stream down also. It is at this moment that the photograph was taken.



(a) (b) (c)



(d) (e) (f)

The food coloring will appear to obtain an upside-down umbrella effect, known as the Rayleigh-Taylor instability. “When a fluid rests atop another fluid with less density, this instability arises. Consequently, the less dense fluid underneath starts moving upward, mixing with the denser fluid.” [2] This effect is caused by an imbalance of capillary pressures between the three fluids—oil, water, and food coloring. Capillary pressure must squeeze the food coloring from the bottom of the oil layer into the water layer, creating a tension between the fluids that causes the droplet of food coloring to break up and stream downward.

The blue food coloring, coconut oil, and water were the three fluids that made up this image. The food coloring was “Assorted Food Colors and Egg Dye,” from Safeway, the coconut oil was “Organic Virgin Coconut Oil,” from Trader Joe’s, and the water was from the tap. The water needs to be above 76°F so that the coconut oil can be in a liquidus state. For the image capture, natural sunlight through a white curtain in the background was used, and the camera flash remained off.

The camera used for this image was a NIKON D5200. The specs were as follows:

- Exposure time: 1/125 sec.
- ISO Speed: ISO-200
- Focal length: 46 mm
- Max Aperture: 4.8

The dimensions of the original image were 4000x6000 pixels, whereas the final image was 345x609 pixels. The post-processing of this image included flipping the image vertically and increasing the contrast and saturation. Too much of an increase of either caused a significant loss in essential detail, therefore there was not a large amount of processing done.

This image reveals the beauty and complexity of the Rayleigh-Taylor instability. The clarity of the final image could have been better-- the photo-editing process seems to have eliminated a lot of the data that was originally captured in this image. The intent, however, was fulfilled. The feel and look of this image was meant to be clean and serene, and that’s what came of the final product.

WORKS CITED

1. Jenae. “Fireworks in a Jar – I Can Teach My Child!” *I Can Teach My Child.* 22 May 2012. Web. 23 Sept. 2015
2. Jacobsmeyer, Brian. “Mixing Physics: Rayleigh-Taylor Instabilities.” *Physics Central.* Physics Central, 23 Sept. 2015. Web. 24 Sept. 2015.