Team Second Image: Report

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The purpose of this image was to continue team-centered exploration into the world of flow visualization. The intent of this image was to capture a fluid phenomenon in a visually appealing way, whilst exploring personally unknown territory. I was unsure of which regime of the rope-coiling effect I wanted to capture (inertial or gravitational) so I took many pictures to find one that I liked.

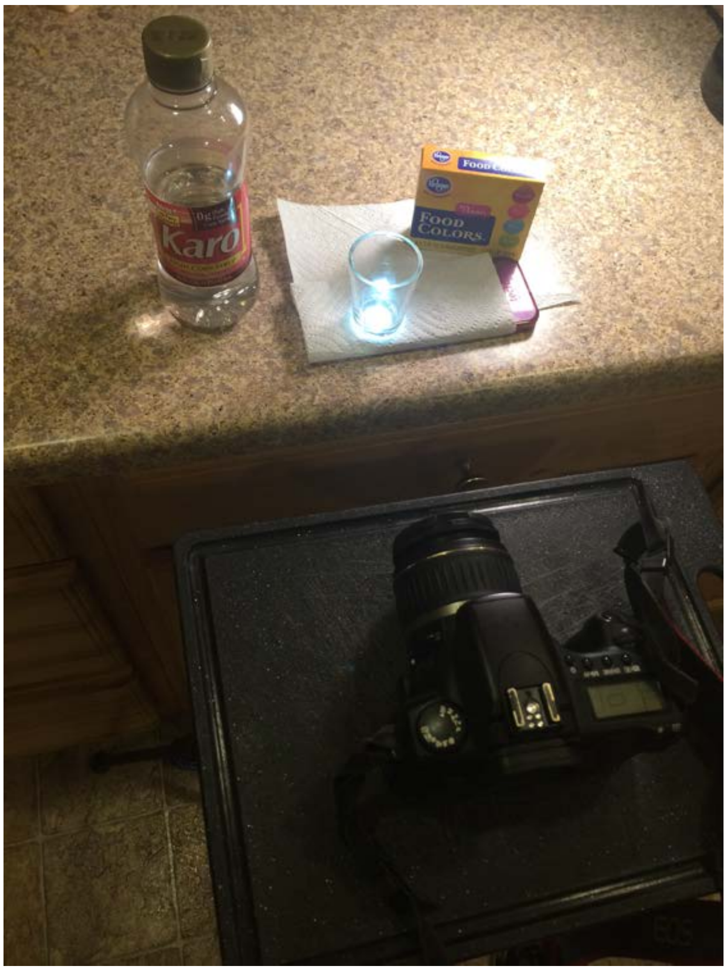

Figure 1: Apparatus for image capture

The apparatus I used to capture this image was very simple (shown in Figure 1). There is a shot glass sitting on top of an iPhone light, covered by a paper towel to soften the glow. There is also a desk lamp shining on the scene from the right. Additionally, there is a red background to add color variation (not shown in Figure 1). To create the effect, I simply added a small amount of food coloring to the shot glass, and then poured in the corn syrup from above, taking pictures all the while. It took about 450 pictures to get one that I was satisfied with.

To get a crisp image, the time resolution (shutter speed) had to be pretty quick. In order to calculate an actual shutter speed, it would be quite complex. The velocity of the corn syrup can easily be found at the coil by using Bernoulli's equation $\left(\frac{P}{\rho} + \frac{1}{2}v^2 + gz = const\right)$. However, once the fluid starts coiling, centripetal effects come into play since the flow becomes rotational. Depending on the height the fluid is dropped from, the fluid will coil at a different rate. The velocity is calculable, but beyond the scope of this paper. The shutter speed that was eventually used for this image was 1/2000 s, which makes sense due to the quick nature of this phenomenon.

In terms of the actual physics-taking place in the rope-coiling effect, it can be quite complicated. In basic terms, the fallen fluid does not settle immediately due to the high viscosity, so the falling fluid must move out of the way in order to keep a steady flow from the source. This results in a coiling effect, since it is the most controlled behavior for the falling fluid to follow. When dropping the fluid from a higher height, the fluid stream has a much smaller radius and a much higher velocity by the time it reaches the glass (due to the Bernoulli effect). Therefore, it must coil more rapidly to keep up with the mass flow rate of the fluid. However, when dropped form a lower height the opposite is also true; the radius of flow is larger and the coiling rate is lower. I aimed to have a slower coiling rate so that the image could be more easily captured.

The visualization technique was pretty simple. Adequate lighting had to be used since the shutter speed had to be so low. Also, a fairly high ISO had to be incorporated since not that much light was taken in by the camera. To capture this phenomenon in focus was a little bit tricky, as well. It was difficult to control the exact placement of the flowing fluid in the shot glass, so many pictures had to be taken and a “hope for the best” technique was used. Many images were captured in the right location from the lens, but to get one that was perfectly in focus in terms of shutter speed and all other parameters turned out to be very difficult. A more sophisticated setup could have been used, but the materials for such were not readily available.

In terms of a photographic technique, a lot of this process was trial-and-error. A low aperture and a fast shutter speed would ensure an image that was in focus, but a fairly high ISO had to be used to make sure that the image had a high enough exposure. The camera that I used is a Canon EOS 20D. The F-number was 5.6, and the focal length was 55. The lens is the standard lens that comes with the camera, EF-S 18-55mm f/3.5-5.6 IS II. The camera was held about 2 feet away from the ink droplet. The shutter speed was 1/2000 s, with ISO 400. The original image was 3,504 X 2,336 pixels. Again, I knew that I needed a small field of view and a fast shutter speed, but it was a matter of playing with the settings until it worked well.

Overall, I’m very satisfied with how this image turned out. The original image (Figure 2) was very dark, so the exposure had to be increased a fair amount. Also, things like the contrast and saturation were boosted so that the image really popped, especially with the blue food coloring that can’t be seen very well. The fluid physics are shown fairly well, demonstrating the rope-coiling effect very well. To develop this idea further I could use a more sophisticated setup, including more colors, to better capture this phenomenon in an even more stunningly visual way. However, I am indeed pleased with the product and I enjoy the simplicity of this photo.

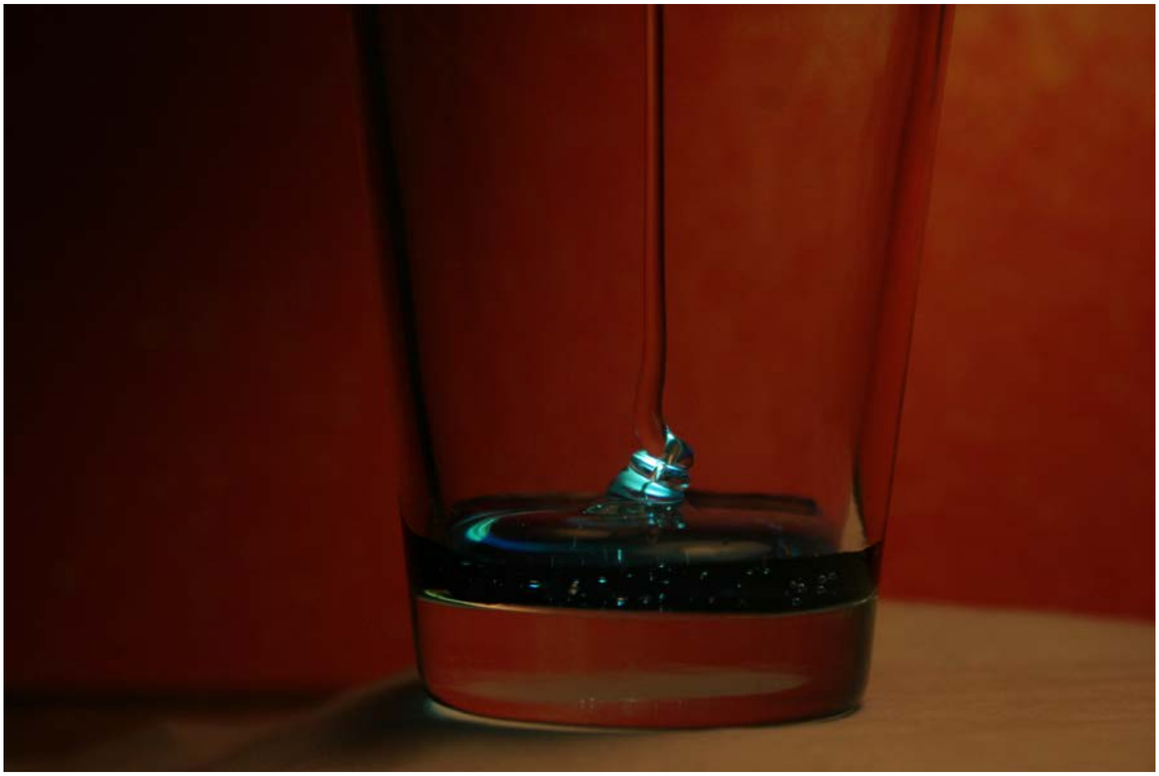

Figure 2: Original Image