2021 Fall - Image First Report

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I. Intent of Image

The original intent of this project was to witness and capture the effects of surface tension on a fluid. Using common materials, I hoped to use dish soap to break the surface tension of a milk fluid, and use seeded boundaries to visualize the motion of the fluid. While I was able to view this phenomenon, it was not the highlight of the experiment. After the surface tension phenomenon subsided, I stirred the fluid and it became a beautiful mixture of color and fluids which far surpassed the images created by the original experimentation project. This final image is shown in figure 1.

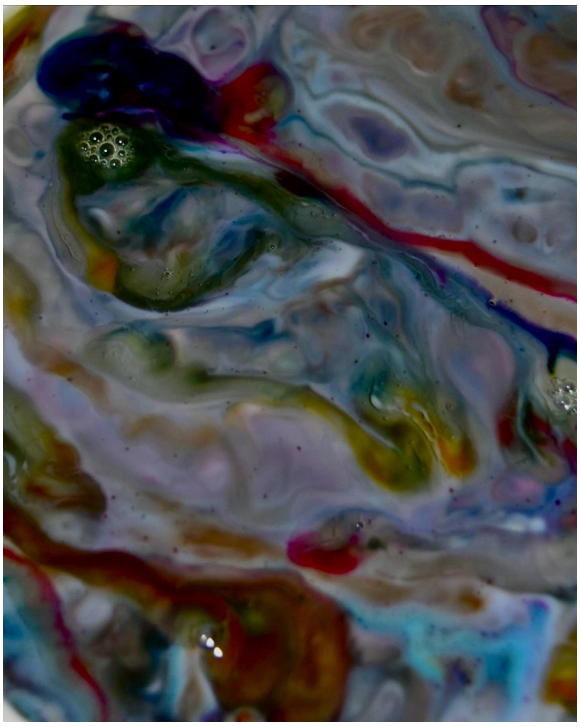


Figure 1: *Final Photo Image, showing dye mixed with milk in turbulent flow.*

II. Flow Description

The flow of the liquid was created on top of a shallow white plate. Figure 2 shows the resources used to create the effect. The first step of the set up was to fill the platter with ¼ cup of milk. Then I add drops of dye in various colors. These droplets were supposed to sit on the top of the fluid, but they were too large and they broke through the surface tension and fell to the bottom of the plate frequently.

Figure 2: *Supplies used for the experiment: 2% Milk, Dawn Dish Soap, Nikon D5500 Camera, Purple, Orange, Blue and Pink Food Dye, ¼ C Measuring Cup, Q- Tips, and 5" White Round Platter. Items are pictured in front of the white box created for the photos.*

The next step is to add a drop of soap to the platter. This causes the dye to spread away from the source of soap because it breaks the surface tension on the platter. Due to the majority of the dye sinking to the bottom of the plate, this was not sufficient to create a very aesthetic photo. Stirring up the dye from the bottom of the platter yielded much more impressive photos, even though it did not directly meet the original intent.

In the original experiment and the final experiment, we observe turbulent flow using the seeded boundary areas of the dye. The bubbles, and picturesque flow make us assure that the fluid is in turbulent flow. To confirm this idea, we calculate the Reynolds (Re) number in equation 1, which is the equation for the Reynolds number over a flat plate.

$$Re_{plate} = \frac{\rho v l}{\mu}\ ^{[1]} \qquad \text{Eq.1}$$

$$\rho_{milk} = 1030\ [\frac{kg}{m^3}]^{[1]}$$

$$v_{milk} = .1\ [m/s]$$

$$l_{platter} = 5\ [in],\ .127\ [m]$$

$$\mu_{milk} = 1.13\times10^{-6}\ [m^2/s]^{[1]}$$

The velocity of the milk is estimated by comparing the observed speed of the milk during the experiment. This makes perfect sense, because this is right at the boundary for turbulent flow. Since the plate was about .1 m, the fluid can easily reach across the whole plate in one second when stirred. I could use a larger velocity, but this provides an accurate estimation to be used to find the Re number. Using the density, velocity, dimensions, and kinematic viscosity as shown

above we find the Re number is 11.6×10^6. The main focus of the final photo was the turbulent flow of the fluid, so it worked out perfectly.

III. Visualization Technique

As alluded to above, seeded boundaries are created by mixing the dye with the milk. When the dye is added to the milk, some of it mixes with the milk, but it remains in separate boundaries so that we can better visualize what the fluid is doing. After a long time, or a large amount of motion, the dye tends to blend together, so it was important to take photos at the beginning of the process before this occurred. Without the dye, we would be unable to clearly see the turbulent flow that was described above and seen in figure 1.

IV. Photographic Technique

To create a good background for the photos, I created a light box using white paper available at my house, this helped reflect the lamp light and sunlight that was available during my experiment. It helped to ensure there was minimal reflection on the fluid from direct light as well. I experimented with a borrowed Digital Nikon D5500, which I was very unfamiliar with. After changing the aperture, F- number, and other settings, the final image camera settings are listed below [2]:

Camera: Nikon D5500
Field View: 12 x 12 cm wide, cropped to 7 x 10
Distance from object: 2 ft
Size: 1620 x 1080
File Size: 187 KB
ISO: 500
F: 4.5
SS: 1/60 s

I experimented with many other settings, but these provided the closest focus. As the camera was borrowed, I was not able to determine which lens was used. These settings as well as the Auto Setting provided the most clear and polished photos from my experiment.

After taking the photo, I completed some post processing. While I experimented with the RGB plane and luminance settings, the final product only required a lowered brightness and slightly increased color value. This allowed the seeded boundaries to be clearly seen and provided contrast that popped significantly. Figure 3 displays the before and after editing of the photo [3].

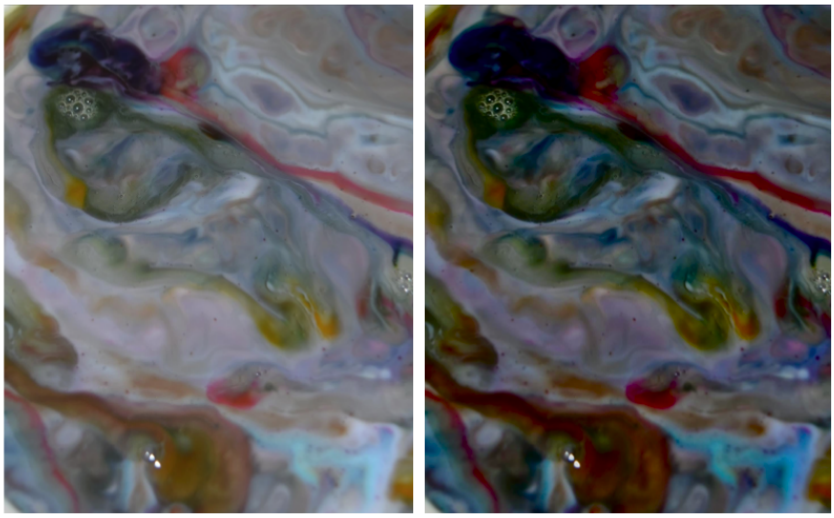


Figure 3: *Before and after postprocessing of the photo.*

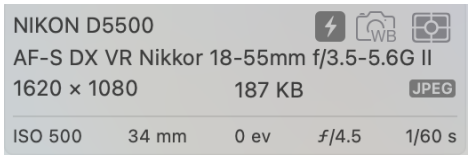
V. Image Commentary

This Image turned out really well. Originally my concerns were that the colors would not stand out well and that the focus was not good enough. After getting feedback about my image and hearing other critiques, I was able to use a bit of crop and post processing to create something which is very aesthetic. I think it clearly shows the turbulent flow. While eventually the dye would run together and blend, the setup gave me adequate time to capture the turbulent flow before the seeded boundaries deteriorated. In order to more fully develop this experiment, I would try to get more familiar with focus and avoid the bubbles that were created during the soap insertion. This would allow for an even clearer fluid flow without the distraction of bubbles and fuzzy edges. Looking into the camera lens and zoom settings would likely help with this. One other improvement would be to use a polarized lens to avoid the small glare in the frame. As a whole I am very happy with how it turned out.

VI. Appendix and References

1. "Physical Properties of Milk." *Physical Properties of Milk | Food Science*, https://www.uoguelph.ca/foodscience/book-page/physical-properties-milk.

2. Camera Specifications from final photo:



3. Post Processing Specifications: