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Get Wet Report
MCEN 4151-001
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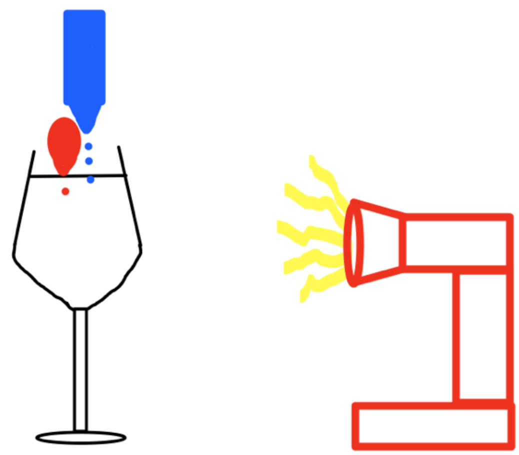
For my first project in the Flow Visualization course I wanted to compare how fluids of different densities behave when being dropped into water. Originally I used food coloring and vegetable oil to conduct this experiment, but after multiple attempts I was not impressed with the images because the oil simply formed a puddle on top of the water due to its low density. I decided to substitute the vegetable oil for dish soap and got a much more interesting display. I had my friend Bryan Heiser add a drop of red food coloring then add continuous drops of dish soap so I could focus on capturing the image.



Here, a wine glass that was 4in wide and 9in tall was filled with water to provide a medium for the other fluids to flow. This photo was taken about fifteen seconds after the first drops were added. There are a few flow phenomena occurring here. First, we see the single drop of food coloring dispersing itself within the glass of water. Since food coloring has similar density and viscosity as water, the only significant force comes from the momentum generated between the dropper and the surface of the water. This momentum causes the food coloring to travel towards the bottom of the glass. Despite this, we can tell water and food coloring have very similar properties because even after fifteen seconds, there was still red at every elevation in the water and some of the motion appears to be in the horizontal direction.

Next we look at the dish soap. It is fairly obvious that the soap is denser than the water and food coloring because of the think layer of soap at the bottom of the glass, but then why is there soap at the top of the glass as well? Hydrogen bonds in water create a membrane like affect called surface tension. The majority of the drops of soap carried enough momentum to break the surface tension and continue sinking to the bottom of the glass. Smaller drops however, generate less momentum and cannot break the surface tension. This is why some of the soap stayed at the top of the water, but only for a second or two. Soap is a surfactant, which means it reduces the surface tension of a liquid[1]. If a drop of soap stayed on top of the water, it didn't take long for it to weaken the surface tension enough that the soap could break through and sink to the bottom.

Accurate Reynolds numbers of the food coloring and soap were not able to be calculated because of the unknown fluid velocities, but by looking at the picture and the equation $R = \frac{inertial\ force}{viscous\ force} = \frac{\rho v D}{\mu}$ we can make an educated guess as to whether the flow was laminar, turbulent, or in the transition region. The velocity of both fluids during the experiment was very low. Since the velocity of the dish soap was low and the viscosity was relatively high, it is safe to assume the soap is in laminar flow with a Reynolds number of less than 2300. For the food coloring, I look at the photo and see laminar flow in the middle of the red and see what looks to be turbulent flow on the outer edges. For this reason, I think the food coloring is in the transition region with a Reynolds number between 2300 and 4000.

To begin this experiment, I purchased Signature Kitchen's assorted food and egg dye from Safeway and chose to use red because it contrasted the blue Dawn Ultra Dishwashing Liquid well. I also felt the white background made the colors stand out more than a black background. A large LED flashlight was placed on the right side of the glass at about a 120˚ angle to try to minimize glare and the camera flash was turned off.

To take this picture, I used the close up (flower) mode on my Nikon D60 DSLR since the lens was only about a foot away from the glass, and the description of this setting on the camera says "emphasis is given to vivid reds and greens", which was what I wanted. Using the wine glass as a reference, the field of view was found to be about 10 inches. The lens I used was a Nikon DX AF-S NIKKOR 18-55mm 1:3.5-5.6G and the focal length was 18mm for this picture. When capturing this image, the aperture was f/3.8, the shutter speed was 1/60, and the ISO was 200. To edit the photo, I used Pixlr X which is a free image editing software online. I increased the brightness, enhanced the colors, cropped the image, and used curves to adjust the contrast.

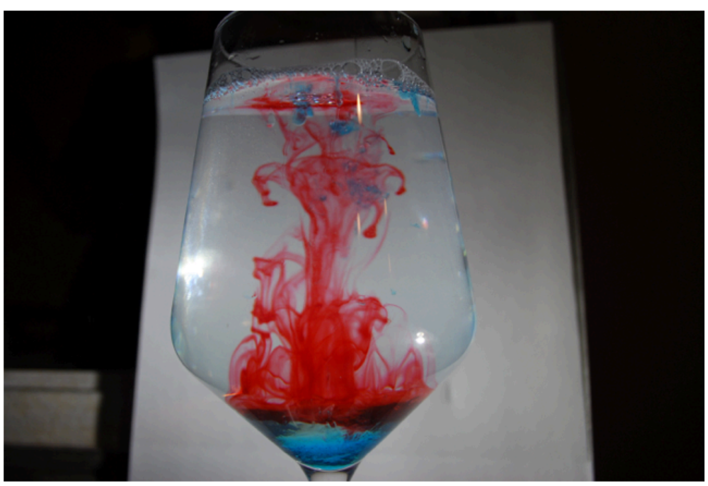


Figure 1: Original image 3872 x 2592 pixels

Figure 2: Edited image 2550 x 3300 pixels

This was my first time making a serious effort into capturing and editing an image. I like the colors I used because they are bright and contrast each other well. The image does demonstrate the different flow behaviors of the two fluids but with an additional twist. The denser soap stayed balled together and settled to the bottom, and the food coloring dispersed in all directions as expected. The affect of surface tension on the soap surprised me, but I think it added an interesting element to the image.

I have learned a lot about photography since starting this class, so there are some things I would like to improve on if I were to do it over again. If I were to retake this image I would increase the aperture. This would give me a larger depth of field so that all of the fluid motion could be captured in focus. I would also try moving my flashlight back or putting a piece of white paper in front of it to scatter the light more. This would hopefully reduce glare and bright spots. Also, when I took this picture my camera was set to save the image as a .JPG which reduces the quality of the image. Next time I will make sure to set it to save as .NEF for the full quality of the image.

References

[1] Arnett, Megan. "Does It Sink or Float? Depends on the Soap!" *Scientific American*, 19 July 2018, www.scientificamerican.com/article/does-it-sink-or-float-depends-on-the-soap/.