Get Wet Report

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The purpose of this assignment was to get exposed to the art of photographing fluids in motion. A large part of photographing fluids has to do with your equipment. In order to capture a nice, clear image, one must be very familiar with the type of camera that they are using and of its capabilities. A person with little to no photography experience might be tempted to use automatic settings because this does not require a lot of knowledge. The issues with using automatic settings is that cameras don't always record how much light is coming in or how far the object that you are trying to focus on is. Through the first weeks of class I learned that becoming familiar with the purpose of each lens feature makes it possible for someone who has no photography experience to capture a good image. For this assignment, I decided to photograph coffee creamer being poured into coffee. Being an avid coffee drinker (although I hardly use creamer), I am very fascinated by the movement of the creamer when it is poured into a dark caffeine beverage. Since coffee creamers tend to be thicker than coffee, these two fluids tend to stay separate when they are not mixed.

For my first attempt at capturing an image, I poured regular milk into hot coffee in a round glass. I had a very difficult time capturing an image and a lot of factors played into this. One of the first problems that I saw when I first poured the milk was that it was spreading fairly easy. It seemed like the milk was too thin, or not viscous enough. This might have been because it was fat free milk and those milks tend to have lower viscosities [1]. This quick spread made it very difficult to capture the separation between the milk and the coffee. When I inspected my images, I found that I was getting a lot of reflections of light around the curvature of the glass. After taking a few initial images, I decided to change a few parameters. The first thing that I decided to change was the type of milk that I was using. It seemed that in order to get a better stream of milk in coffee, I should use an actual coffee creamer. Coffee creamers had larger percentages of fat and would therefore be more viscous and have a higher density. I also decided to change the temperature of the coffee. Fluids tend to have a lower viscosity at higher temperatures [2]. Having a larger viscosity would keep the coffee from moving around when impacted by the creamer, so I decided to use iced coffee instead of hot coffee. The last thing I decided to change was the container that I was using. A lot of the reflections were caused by the curvature of the glass, so I decided to use a small rectangular glass vase that is about 6x4 inches when looking at it from the front.

Making all of these changes made for a better image. Although a lot of the glares disappeared by using a flat glass, I was still getting a few glares from the light. I decided to capture my images with these small glares and attempt to fix them in post-processing. Finding the right settings on the camera was difficult. It was hard to find a short enough shutter speed to capture the movement of the fluid without compromising any of the light. Finding the right ISO was also difficult because I needed a high sensitivity without getting a grainy image. In the end I was able to capture a pretty good image. I really liked the stream of creamer that I was able to capture in my image. You are able to see the physics of the coffee and the creamer when they interact with each other. When the creamer is poured into the coffee, the creamer exerts enough force on the coffee to break the surface tension. When the creamer touches the bottom of the glass, it experiences a force that causes it to bounce back up and create cloud-like shapes. When the creamer touches the bottom of the container, it loses energy and this energy is then

transferred to the coffee. This energy causes the coffee to move outwards and therefore it the coffee and creamer begin to mix. Naturally, colder fluids will move towards the bottom as warmer fluids will rise. In this case, both of the fluids were cold. I would say the creamer's reaction to sink to the bottom was due to it not only being colder than the coffee but also having a larger density. If we let the coffee and the creamer sit for a while, we would notice that eventually they mix naturally. This is because the temperatures need time to be in equilibrium. When the two fluids mix, we can expect that the temperature of both of the fluids in the glass are the same. This is similar to the physics that happens in many different situations in our universe, including the mixture of Earth's mantle. [3]

To determine whether this flow is laminar or turbulent, the Reynold's number can be calculated. It is important to identify this flow as internal or external because the critical Reynold's number is different for these two situations. This flow is an internal flow because it is confined by an enclosed surface. The pour velocity needs to be calculated. It took approximately 6.7 seconds to fill up a 80 mL container with a diameter of 2.5 inches (0.0635 m). To calculate the velocity we simply determine the volumetric flow rate and divide by the cross sectional are of the 80 mL container.

$$V_f r = V/t$$
$$V_f r = \frac{80mL}{6.7s}$$
$$V_f r = 11.94mL/s$$
$$V_f r = .00001194m^3/s$$
$$v = \frac{0.00001194m^3/s}{\pi/4 * d^2}$$
$$v = .00377m/s$$

With these calculations, we can now calculate the Reynold's number of the flow.

$$Re = \rho v D/\mu$$
$$Re = \frac{(1008\frac{kg}{m^3})(.00377\frac{m}{s})(0.003175m)}{.00289Pas}$$
$$Re = 4.2$$

Where the density of cream is 1008 kg/m^3 [1] and the viscosity of cream is about 0.00289 Pas [4]. The diameter or the stream can be estimated from the image. Knowing that the inner width of the container is five inches, the diameter of the stream is about 1/8 of an inch, or 0.003175 m. This Reynolds number of 4.2 is well below the Reynolds number of 2100 for an internal flow, which means that this flow is laminar.

Lighting plays a very important role in capturing a good image. Finding the right light was a challenge because of the bad lighting in my apartment. Initially, I attempted using a few bike lights at a distance far away enough to reduce glare. I attempted taking the images with the experiment set up in a corner to avoid shadows, but I really did not like how the images turned out. I then decided to move closer to my porch doors and take advantage of the natural light. The porch doors allowed for a lot of light to come in from the right side of my image. I played around with the angles a little bit and was able to get a pretty well-lit image. My set up was about 3 feet away from the doors.

I played around with the distance from the object to the lens in order to adjust the zoom on my camera and be able to focus on the coffee. The lens was about 12 inches from the front of the glass. The camera that I used for this was a Nikon P510 which is a digital point and shoot. The original images are taken at 4608x3456 pixels. The focal length of my lens ranges from 4.3-180 mm. The f/-number ranges from f/3-5.9. For the image that I captured, the aperture that I used was 3.3, the ISO was 1600 and the shutter speed was 1/200 of a second. I decided to crop my image to cut out some of the unnecessary white space. The size of my cropped image was 4176x2152 pixels. To calculate the focal length the image distance and the object distance need to be known. The object distance in this case was about 1 foot, or 30.48 centimeters. The image distance is 10 centimeters.

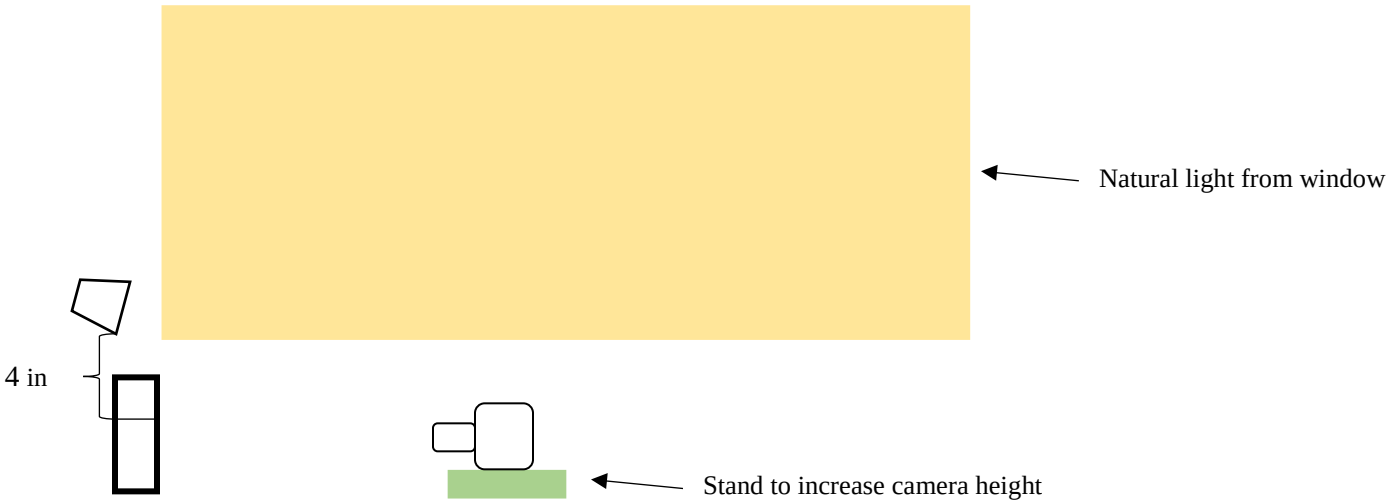
$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$
$$f = 7.5cm$$

This gives a focal length of 7.5 centimeters.

In post processing, I used an S-curves to make the coffee look darker and the cream look lighter. I also used the clone brush to darken some of the coffee that seemed a little lighter. I did this to make the white cream really stand out. Additionally, I used the dodge/blur tool. I really like this tool because it allowed me to darken and lighten a few areas without changing the original color. Finally, I used the brush to make the background on the top white. This got rid of a lot of the reflections on the top of the glass and made the stream of cream stand out from the white background.

Overall, I really enjoyed working on this project. It was more challenging than I expected, but it was quite rewarding to get a good image. I like my image overall. I believe that I captured the turbulent movements of cream being poured into coffee. I also really liked how the coffee showed red tones. The resolution on my image could use some improvement. I believe that the steam and movement of the creamer could have been captured better if I used a shorter shutter speed. Much of the feedback that I received mentioned that my image looked like a cross-sectional view of a glass. This was something that I did not think about and I learned to like my image a little more because of this.

Side View



[1] Goff, H.D., Hill A.R., "Dairy Chemistry and Physics", Dairy Science and Technology Handbook, VCH Publishers, 1993, Vol.1

[2] 17, Chapter. *This Section, You Will Learn How the Size and Shape of a Molecule Influences a Liquid's Viscosity, and How* (n.d.): n. pag. Web.

[3] Wettlaufer, John S. "The Universe in a Cup of Coffee." *Phys. Today Physics Today* 64.5 (2011): 66. Web.

[4] "Viscosity of Foods." *Viscosity of Foods*. N.p., n.d. Web. 24 Sept. 2015. <http://www.engineeringtoolbox.com/absolute-viscosity-foods-d_1827.html>.