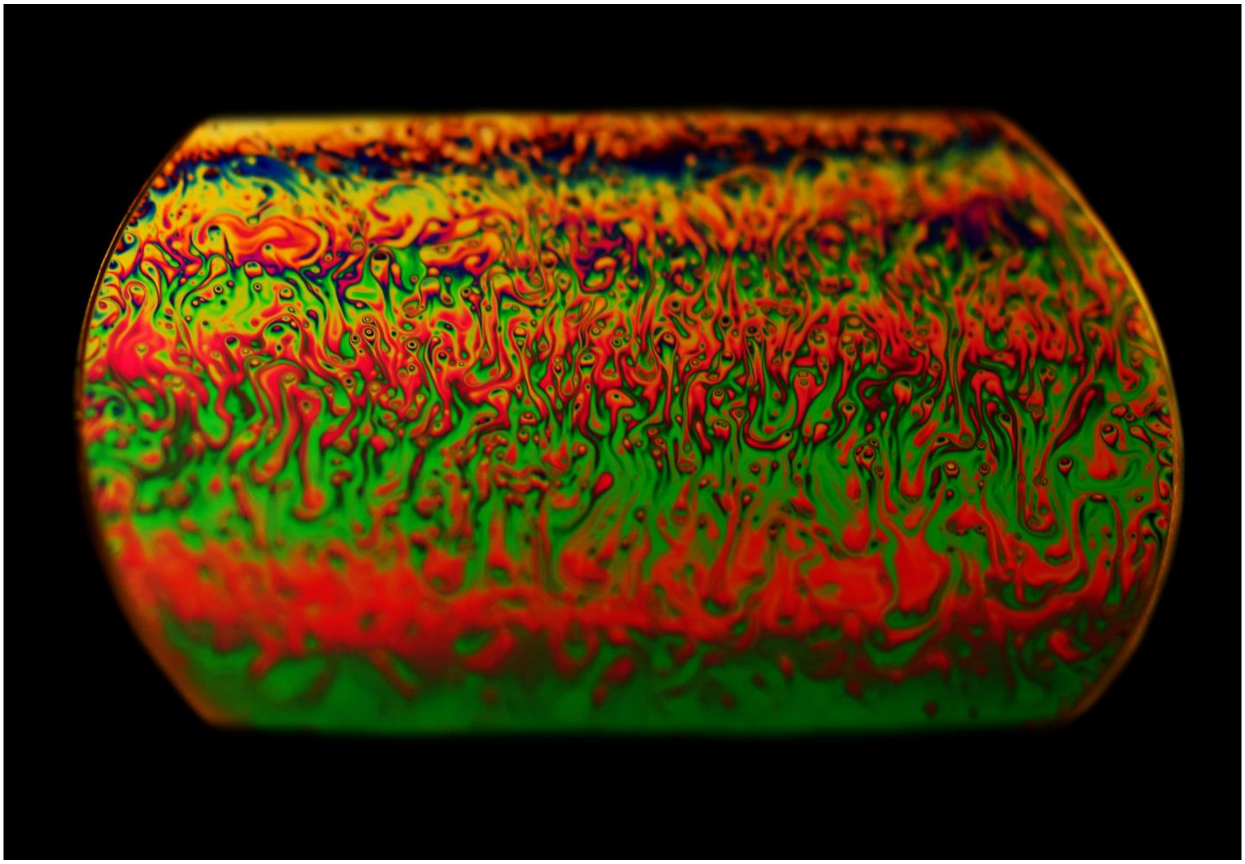
Bubble film

TEAM FIRST IMAGE

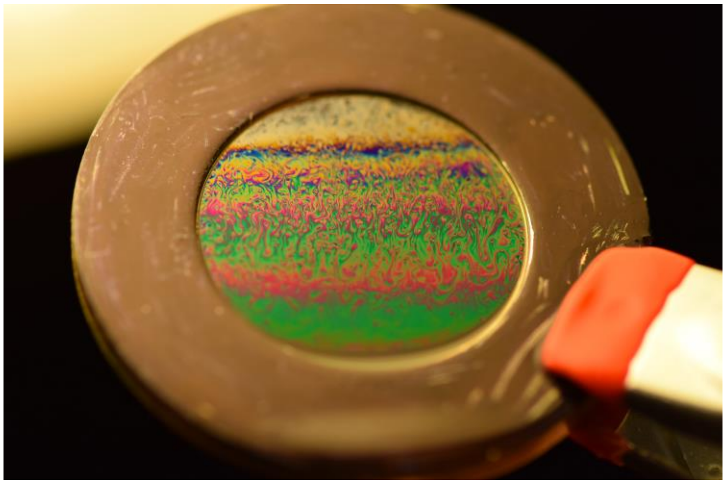


ERICK PENA | Flow Visualization | November 16, 2015

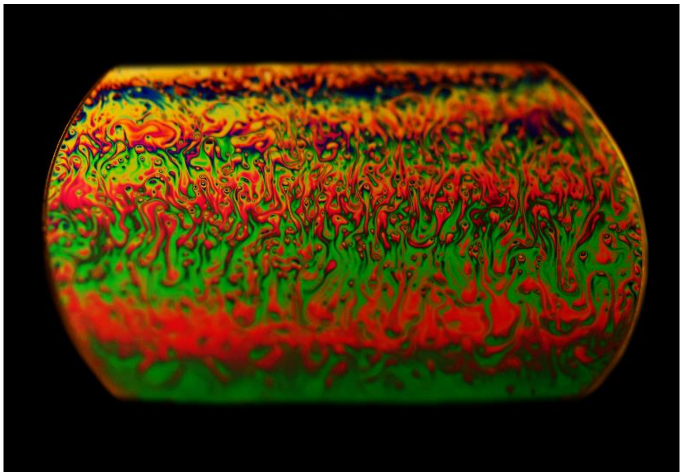
Goal

The purpose of the group image was to do research of flow visualization and as a group decide on a fluid phenomenon. The image was selected based on two criteria: artistic value and adequate display of fluid physics. The goal of this flow visualization is to capture the fluid's brilliant colors in the soap film. Before this class I had not put too much attention to the colors on a bubble. This Idea came from looking at pictures on the Flow Visualization[1] web galleries.

In Figure 1 we see two images, a) is the edited version of the original photograph b). The image processing that was made to the photo was to adjust the curves tool in Gimp to enhance the color. The image was also cropped by almost half in both directions x and y as you can see in Figure 1. I had colored the washer black with a sharpie hoping that it would not reflect a lot of light, to allow the focus to be on the flow. When the sharpie did not work I colored the edges with a tool in Gimp. The purpose of the black background it to draw the viewer's eyes to the flow and reduce other distractions. As you can see the focus is more concentrated in the center than on the top edges, so I decided to crop part of the top and bottom for two reasons: one because the washer was at an angle this made the picture seem more symmetric, second because I was not losing a lot of flow clarity.



(a) Original Dimensions: 6000 X 4000



(b) Cropped Dimensions: 3079 X 2128

Figure 1: (a) on the right is the raw image. (b) On the left is the edited image using curves in Gimp.

Team

For this assignment, I was assigned to a group of two other members, consisting of the following members

1. Erick Pena
2. Daniel Patrick Maguire
3. Stefan Schultz

Materials

[1] Course Flow Visualization Website

This is a list of materials that will be needed to produce a similar photograph as seen on the cover.

1. Water
2. Blue Dawn soap
3. Glycerin
4. 40 W light bulb
5. 1/8" white plastic
6. 0.831 in diameter washer
7. Miniature 1.9 in long, spring clamp
9. 2'length x 1'height black velvet background
10. NIKON D5300

All of the photos that were shown are taken inside, with the blinds down, and with a 40 WATT lamp that is directly above from circular objects. A black cloth was placed on the background to direct the focus to the flow. The settings for the camera were as fallows.

- No flash
- Distance from lens to object: about 50 mm
- Aperture Value (AV)
- Exposure Compensation: 0
- Focal length 105 mm
- Aperture f/5.6
- Exposure 1/160
- ISO: 250
- Original Dimensions: 6000 X 4000
- Cropped Dimensions: 3079 X 2128

Procedure and set up

To create a similar image as seen above we use a recipe of 2 cups of water, 1 tablespoon of soap blue Dawn, and 2 drops of glycerin. The washer was directly below the a 40 Watt lamp at a 60 degree angle, and the camera was at about 35 degree angle both measured from the normal to the washer. As a diffuser we used a napkin (tissue paper) to diffuse the light and the reflection. The camera was a NIKON D5300 set to Aperture Value (AV) to obtain a clear image. The washer has an outer diameter of 1.447 in and an inner diameter of .831 in as seen in Figure 2a. A close representation of the setup is shown in figure 2b.

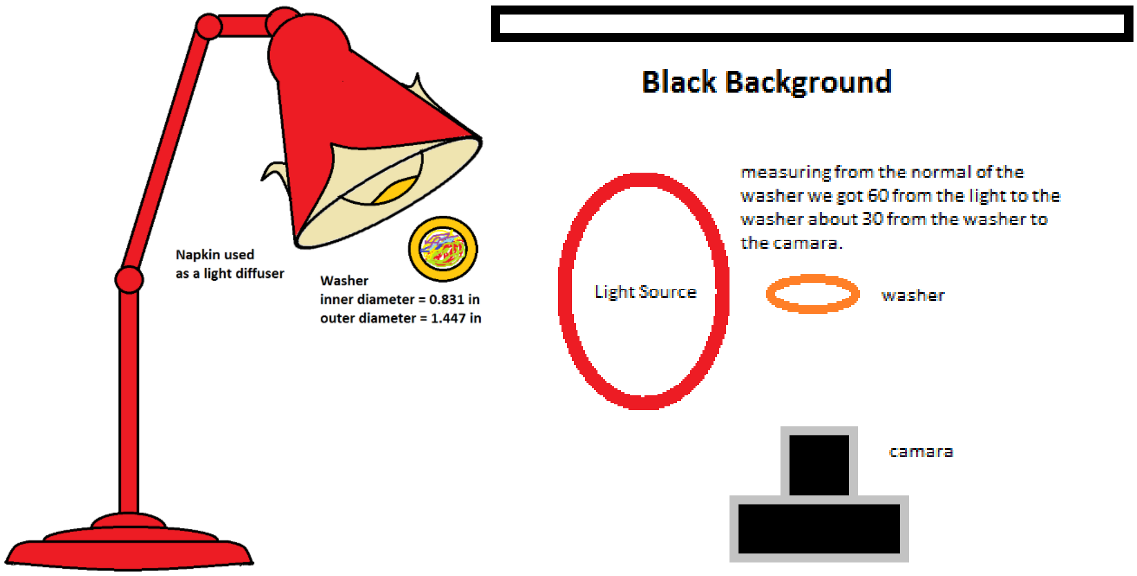


Figure 2: (a) Dimensions of object and info of lamp set up (b) information and set up of lamp, camera, and washer

Fluid Physics

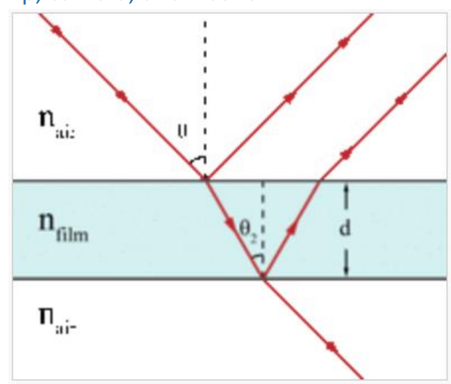


Figure 3; Light incident on a soap. Air surrounds both the top and bottom of the soap film.

The interfering colors from the film are related to the thickness of the soap film. The bands of colors can be seen when the thickness varies[2]. Upon shining light to the soap at a certain angle you can see the variation of thickness that causes the different colors. The angle used in our experiment was about 45 to 60 degrees from the light to the washer and 45 to 60 degrees from the washer to the light. The index of refraction of air is (n_{air}= 1), and the soap film has a larger than one (n_{film} > 1)[3]. The reflection that occurs at the upper of the air film boundary is introduced as a 180 degree phase shift in the reflected wave, due to the refractive index of air being smaller than the index of the film[4]. The light that is diffused at the top of the film-air interface is going to continue to the lower air-film interface where the light will be reflected or transmitted. The refracting that happens at this boundary is not going to change the phase of the reflected wave do to the reason stated previously($n_{film} > n_{air}$). When the light waves encounter interference in the soap film you can see that the wavelength either increases or decreases, this creates the different colors.

Equation 1: constructive interference of reflected light

$$2n_{film}\mathrm{d}\cos(\theta_2) = (\mathrm{m} - \frac{1}{2})\lambda$$

Equation 2: destructive interference of reflected light

$$2n_{film}\mathrm{d}\cos(\theta_2) = \mathrm{m}\lambda$$

[2] "Hyperphysics" Soap Film Interference; http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/soapfilm.html
[3] Wikipedia "Thin-film interference" https://en.wikipedia.org/wiki/Thin-film_interference
[4] Wikipedia "Soap bubble" https://en.wikipedia.org/wiki/Thin-film_interference

The variables are as fallows d is the film thickness, n_{film} is the refractive index of the film, θ_2 is the angle of incidence of the wave on the lower boundary, m is an integer, and λ is the wavelength of light.[5] The bands of color are going from left to right because as the color bands move further apart, the film surfaces become even more parallel while the film become smaller.

violet	380–450 nm
blue	450–495 nm
green	495–570 nm
yellow	570–590 nm
orange	590–620 nm
red	620–750 nm

Figure 4; range of Lambda corresponding to their color.

In Figure 4[6] we see a variance of colors in the visible spectrum from violet to red. Each color has their own range of wavelength in were the specific color appears in the spectrum.

Figure 5 is a plot of the thickness of the film vs the wavelength that produced the color seen in the film. To create the plot in Figure 5 I use Engineering Equation Solver (EES). I used Equation 1, 2 and shells law to relate the angles, lambda and the thickness of the soap film. I varied λ (wavelength from 380 nm to 750 nm) and allowed EES to solve for the thickness d for constructive and destructive interference of reflection Equation 1 and 2. The vertical lines is showing the range of each color in the line. In Figure 5 we see that the thickest color is red with violet being the thinnest. In the edited image created for the flow visualization class we see that the blue and violet colors are on the top and the thicker colors are at the bottom such as reds and greens and a bit of orange seen in the original. This makes sense because the washer was facing downward.

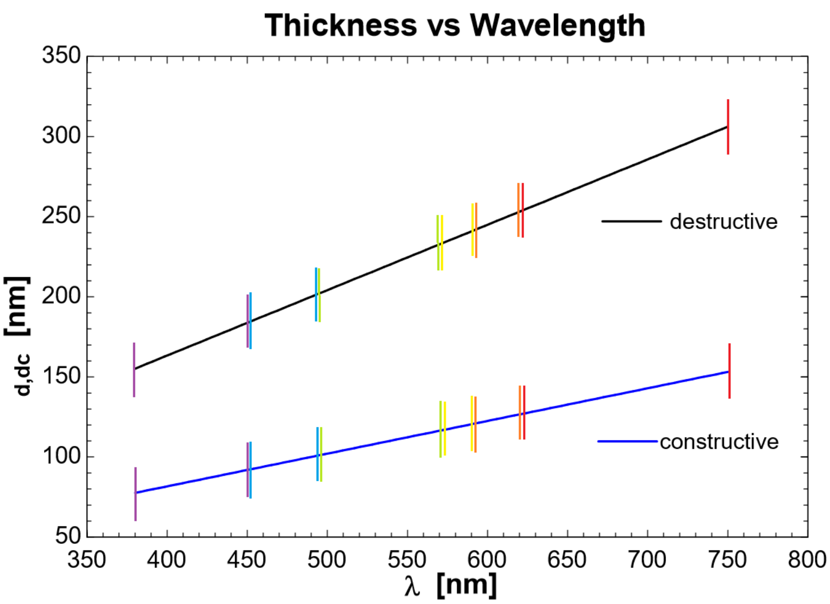


Figure 5; this is a plot of the thickness of the film vs lambda with a theta of 60 degrees going into the film from the normal.

Conclusion

In doing this experiment it brought me a better understanding about bubbles and soap film. The physics are very interesting, and I learned that based on the thickness of the film at a certain angle you can see all the different colors in the visible spectrum. As a team we showed the effectively of interference physics of a soap film. In terms of individual editing this image jumped out at me and made me think of an old fashion 3D effect with the intensity of the red and green. My intention was also to clearly define and reduce distractions and any excessive backgrounds. What I would do to make a better image would be to not increase the contrast as much, also to leave the center where the film is colored and the rest black and white. If I were to recreate this

[5] Wikipedia "Soap bubble" https://en.wikipedia.org/wiki/Thin-film_interference
[6] Visible spectrum; https://en.wikipedia.org/wiki/Visible_spectrum

experiment I would focus in capturing an image that involved critical fall or even a video that develops and ends with critical fall phenomenon.