Gardner Nichols
MCEN 4151
Group 3 Report

For the final group assignment in the Flow Visualization class at the University of Colorado, soap bubbles became the focus. My room mate, Robert Macmillan, helped me with this project by blowing bubbles while I took pictures. After seeing several amazing pictures of bursting bubbles taken by William Horton (http://williamhortonphotography.com/my-portfolio/soap-bubbles/), I became inspired to try my hand at photographing a bubble. My intent was to capture the surface tension of a soap bubble in an interesting and aesthetically pleasing picture.

The apparatus used to produce the bubbles in this image was a simple pipe cleaner. A makeshift lighting studio was created by hanging a strip of white LED lights between two chairs and clipping a florescent work lamp to one of the chairs. A black bath towel was hung on another chair to create a black background. A picture of this set up can be seen in Figure 1.

Figure 1: A picture of the makeshift studio.

The picture, edited and unedited can be seen in Figure 2 and Figure 3 respectively. From a quick observation it is easy to understand what is happening in the picture. Having been bent into roughly a 1" diameter circle, the black pipe cleaner on the right is blown into after being soaked in the bubble solution. The resulting bubble isn't perfectly round because the internal forces acting on each part of the bubble aren't equal to the external forces. When the bubble broke away from the pipe cleaner, it promptly assumed a perfect sphere due to the surface tension force and atmospheric pressure force on the outside being equal to the internal bubble pressure force. The only thing holding the bubble together in the thin film of soapy water was the surface tension resisting the pressure differential between the outside atmosphere and inside the bubble.

Surface tension is the attraction of particles in a thin film. Surface tension will normally change the shape of a thin film to have the smallest surface area, which is why bubbles turn into spheres, rather than cubes. While the surface tension of plain water is higher than that of soap water (Sorensen, 1992), soap water is normally used to create bubbles. Soap water mainly limits evaporation and decreases surface tension enough for a bubble to not collapse after creation. Some sort of glycerin can also be used to decrease the amount of drainage that happens on the bubbles surface, thus maintaining the thin film thickness. In the case of the bubble in Figures 2 and 3, the bubble solution was made of roughly 1 part hand soap, 10 parts water and 5 parts corn syrup. The small pipe cleaner was dipped into the solution and then blown into to create a bubble. The air pressure from Roberts mouth applied roughly uniform force across the 0.8 in^2 area of soap water film. Quickly, the film stretched to about 3 inches wide, thus the surface area increased to roughly 28.2 in^2 before breaking away from the pipe cleaner. The surface tension could be estimated to be around 1.7E-3 lbf/ft (Trefethen, 1969). During the experiment, the air pressure was roughly 12.2 psi. A quick calculation reveals that roughly 345 lbf was acting on the outside of the bubble! This force is, of course, balanced by the internal pressure and surface tension forces acting on the bubble, thus resulting in a net force of zero lbf. The only other force acting on the bubble, gravity, pulls it to the ground.

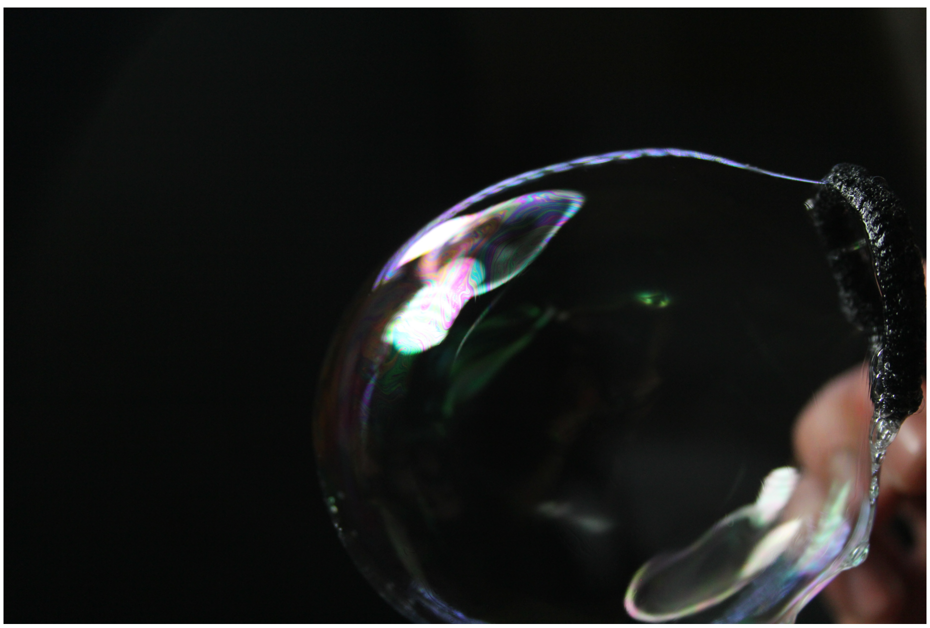

Figure 2: The unedited picture.

There was no real visualization technique used. The iridescent colors of the thin film were captured by adjusting the camera and light. There wasn't any dye or particles added to the soap film with the intent of visualization. While William Horton was able to fully capture the soap film colors across the entire bubble, this experiment failed to do so.

Figure 3: The image after editing in Photoshop.

As stated before, Robert blew the bubbles while I operated the camera. The size of the field of view is roughly 5 inches across. The distance from the object to the lens was roughly 10 inches or less. The lens used was a Canon EF-S 18-55mm f/3.5-5.6 lens. A focal length of 40 was used with an aperture of *f*/5. The ISO was set at 1000 with a shutter speed of 1/800 of a second. The goal with these settings was to get a time resolute picture with enough exposure to minimize post processing. The camera used was a Canon EOS 60D DLSR. The original image size was 5184x3456 pixels while the final image was cropped to 3915x2796 pixels. Photoshop was used for post processing. The only changes done were an increase in exposure and contrast as well as about 50% increase in saturation. Finally, a built-in function called “denoise” was used to decrease the noise as a result of the black background and high ISO.

I believe this image reveals the surface tension of a soap film bubble. The image also reveals the initial unbalanced forces acting in bubble formation. I like the overall image aesthetically. The black background turned out well and the fingers holding the pipe cleaner give the image some context. I dislike the depth of focus. I feel the image could be more resolved and clear. I would also like to get in image more representative of William Horton’s gorgeous bubble pictures. Perhaps with more experimentation with lighting and background, I can capture an image like his.

References:

SORENSEN, CARLD. *Measuring the Surface Tension of Soap Bubbles*., 1992. *ProQuest.* Web. 13 Dec. 2015.

Trefethen, Lloyd. "Surface Tension in Fluid Mechanics." *National Committee for Fluid Mechanics Films* (1969). Print.

William Horton Photography (http://williamhortonphotography.com/)