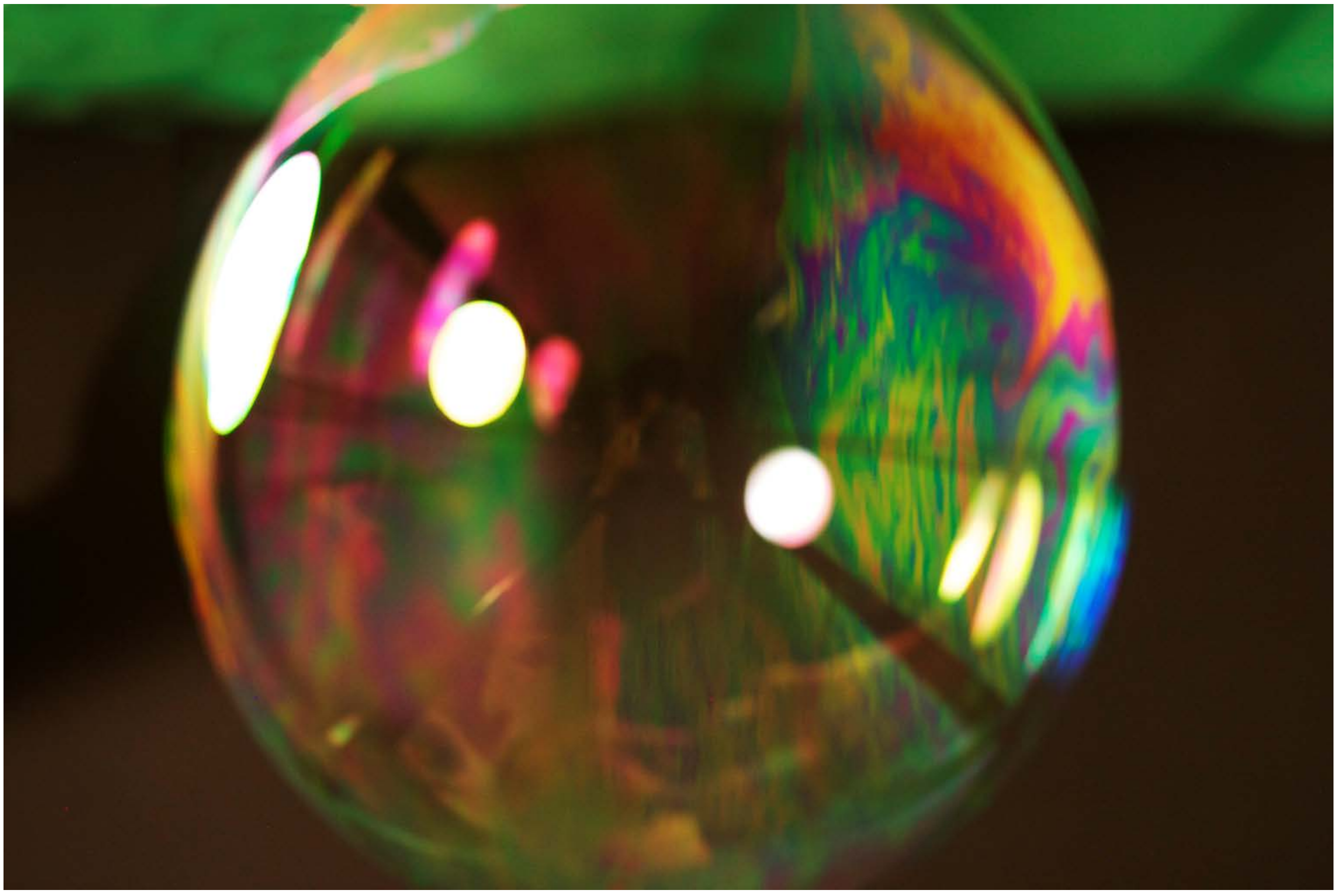


MCEN 4151
Flow Visualization

Instructor:
Jean Hertzberg

Andrew Locke

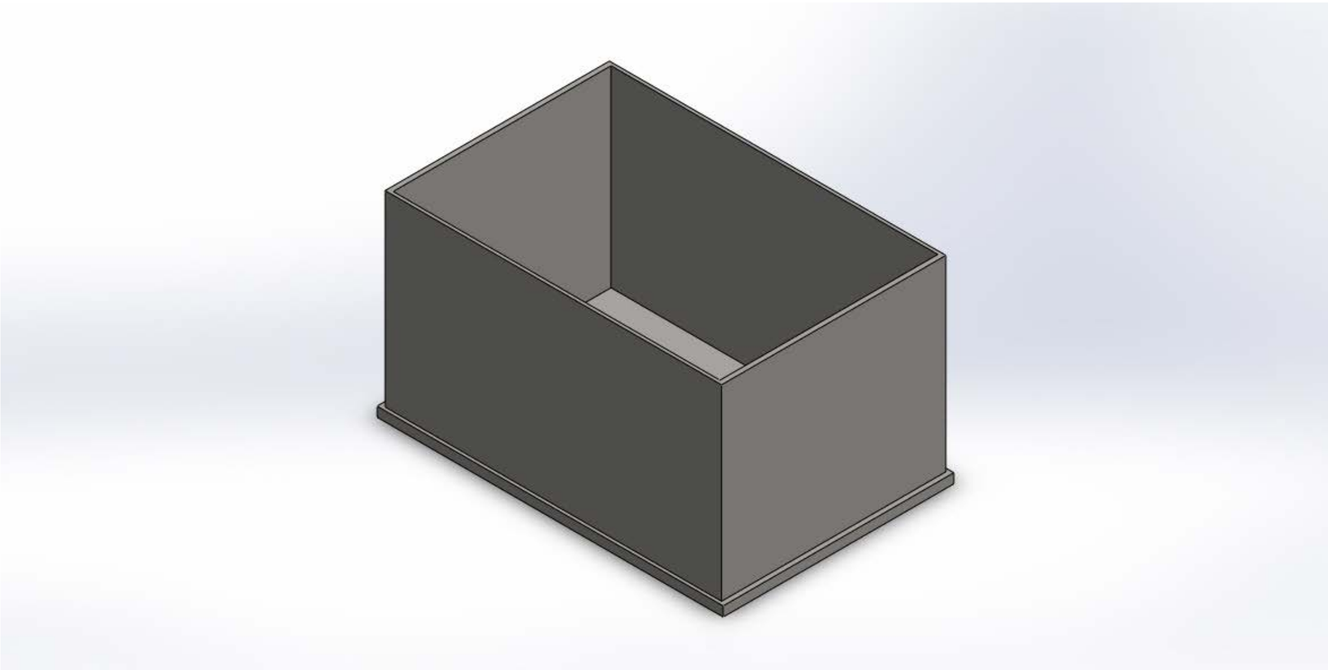
Assignment #4: Team Image

Introduction

The image above shows a soap bubble, lit from the right side, and the resulting surface motion. Additional credit is awarded to Zachary Wehner, Ashlynn Norberg, and Jonathan Severns for aid in the setup and lighting. The intent of the image was originally to use dry ice and water to levitate soap bubbles. During bubble formation, however, we noticed fascinating colored patterns on the surface of the bubble, and this image was captured. Further investigation suggests that the colors are directly related to surface thickness, which will be discussed later. The image was captured on March 18, 2013

Setup

The image below depicts the setup used. I stood approximately fifteen inches away from the bubble. The bubble is approximately four inches in diameter, and was blown through a conventional bubble wand from the local grocer. The bubble was blown over the 36” x 24” x 20” tank shown below, which inconsequentially was filled with a dry ice and warm water mixture (approx. 30 degrees Celsius water).



The Physics

Light scattering can be thought of as the deflection of a ray from a straight path, for example by the interface between two media. In this case, the two media are the inner and outer surface of the bubble. The scattering is occurring because the thickness of the two media is approximately equal to the wavelength of the incoming light. As a result, an estimate for the average thickness of the bubble can be found using the following color wavelength definitions:

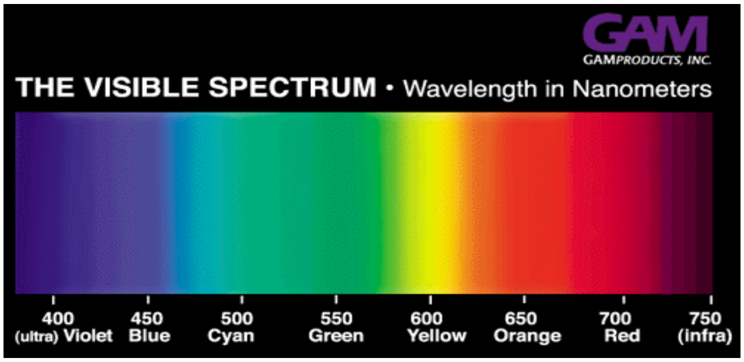


Photo courtesy of Macalester.edu

If time permitted, I would like to develop a program that could analyze the color values in each pixel, and report the total percentages of each color present in the photo. With that result, a more precise estimation of the bubble's thickness could be obtained. However, I do not posses the computing techniques required. As such, I will assume the photo is around 50% green (lambda = 550nm), 25% orange (lambda = 625nm), 10% red (lambda = 700nm), and 15% transparent (lambda = 900nm, beyond the visible spectrum).

From these values, the average thickness of the bubble is estimated to be:

$$t = 0.5 * 550\text{nm} + 0.25 * 625\text{nm} + 0.15 * 900\text{nm} + 0.10 * 700\text{nm}$$

$$t = 6.3625\text{e} - 7m, i.e. 636.25 nanometers$$

Technique and Post Processing

No special techniques were employed. The lighting consisted of two table lamps, both placed on one side of the bubble. Photoshop was utilized to remove Jonathan's arm, which was in the upper let hand corner of the shot. The contrast curves were adjusted slightly. No other post-image editing was done. The unedited shot is shown below:

Camera Technique

FOV Approximately 2 feet

Distance from object to lens: 15 inches

Lens Focal Length: 60mm
Digital camera: Canon EOS DIGITAL REBEL 3072 x 2048
F-stop: not specified
Exposure time: 1/60s
ISO: 800
Aperature: 2.79796

Intent and Assessment

The originally desired effect was circumvented in favor of the stunning colors shown during bubble formation. In this regard, I am very happy with the quality of the image, and would not choose to change anything if I were to redo it. I would like to do some future work with new bubble mixtures, as well as a computational model using pixel color values to have a better estimate of the bubble's thickness.

References

http://en.wikipedia.org/wiki/Light_scattering
http://www.macalester.edu/psychology/whathap/UBNRP/visionwebsite04/achromatopsia%20frames.html