Refraction Angles

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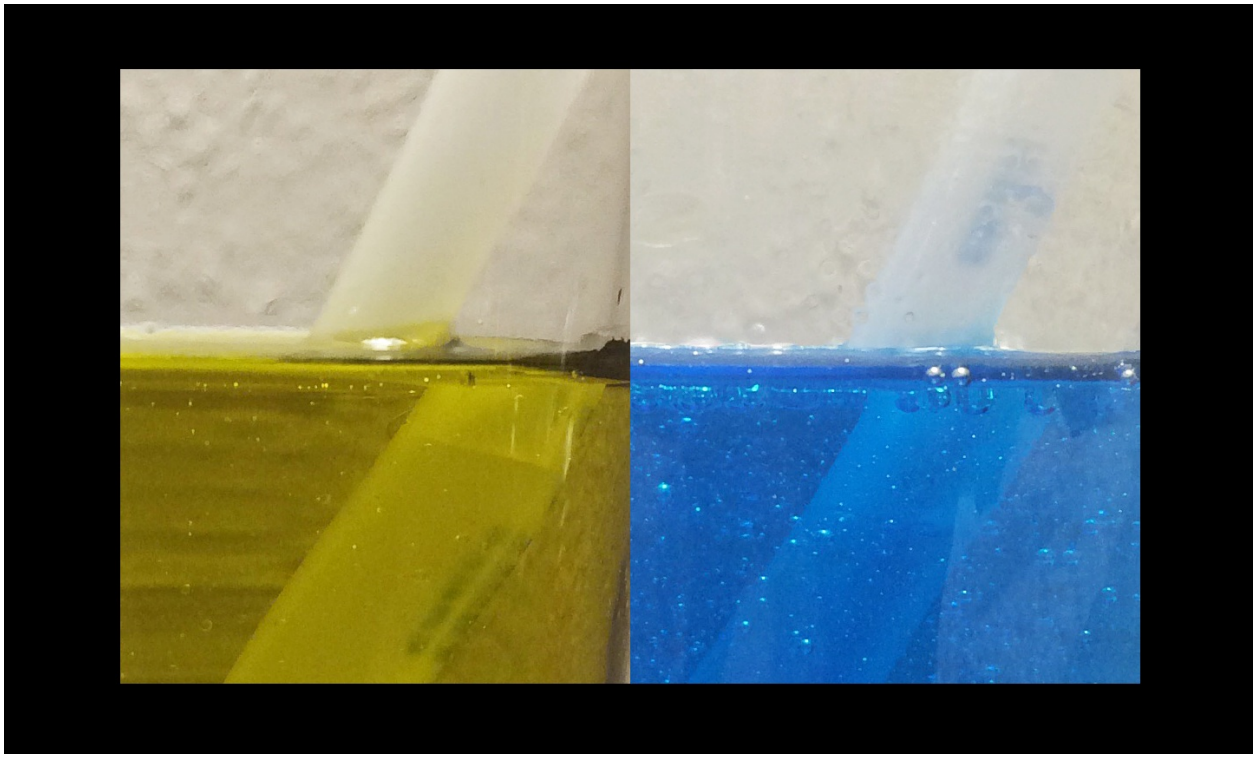

Introduction

This image was taken for the third group assignment for our Flow Visualization course. There are many different approaches that could have been taken in order to show a phenomenon with fluids. This image was taken in attempt to show of how light refracts through different density substances. The refraction of light is the angle of which the light is seen through the fluid due to the speed of light through that medium. This is how the index of refraction will be calculated and compared for the two different fluids.

The Setup

To set this image up, a light (60 Watt Bulb) was positioned directly above the subject. Seen in the picture is a pen casing leaning against the inside of a 16oz glass. It holds the same position in each image. In the image on the left, the fluid seen is olive oil. To show this phenomenon accurately, olive oil was poured into the glass about 4.5 inches high. This is the same set up for the image on the right, which is Dawn dish soap. The background is a white wall, and the camera was facing perpendicular to the glass about 4 inches away.

Understanding the Phenomenon

Everything we see is due to light bouncing off of a surface causing colors and shapes. This is a very interesting topic when it comes to water. I'm sure that at some point, most people have realized that when their arm is underwater, it looks like it is bent. This is due to the speed of light traveling through water at a slower rate than which we see in normal air. The more dense the liquid, the slower light will travel through the substance, causing an angle seen in Figure 1. The index of refraction of olive oil is 1.4677. The index of refraction of dish soap is roughly 1.2 due to the content of water, which it is made of [1]. These refraction indexes cause an angle from the difference between the index of the medium and the index of air, which is roughly 1.

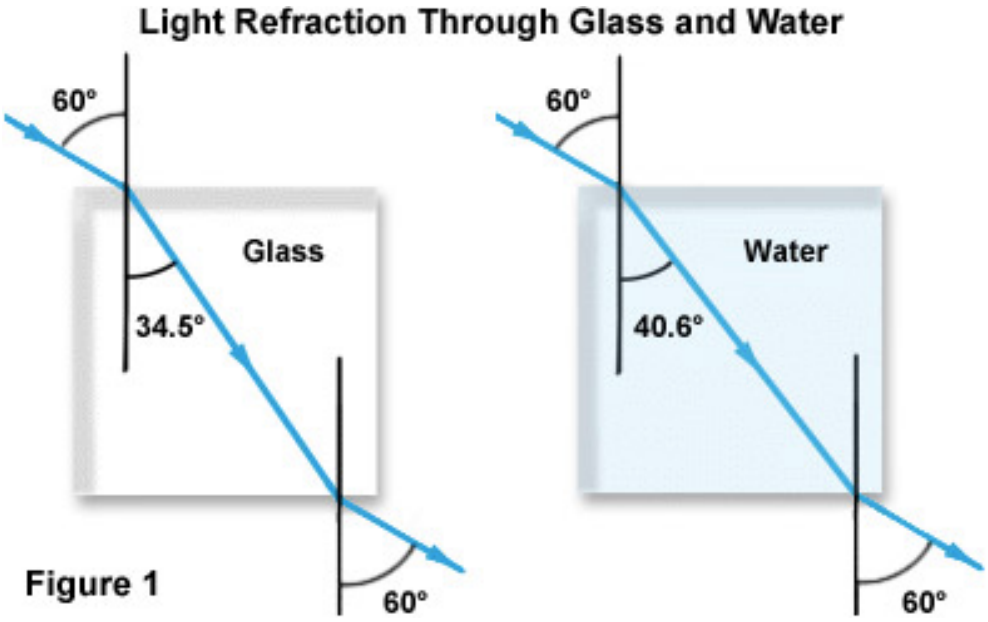

Figure 1 Refraction Angles

From this the speed of the light through the medium can be calculated. The equation for the index of refraction is seen in Equation 1 [3].

$$n = \frac{c}{v} \qquad Equation\ 1$$

In this equation, n represents the refraction index, c represents the speed of light, and v represents the speed of light though the medium that has been chosen. The speed at which light passes through olive oil and soap can be seen below. The speed of light is assumed to be 3(10^8) m/s.

$$v_{olive\ oil} = \frac{3(10^8)}{1.4677} = 2.044\ (10^8) m/s$$

$$v_{soap} = \frac{3(10^8)}{1.2} = 2.5\ (10^8) m/s$$

As shown, the speed of the light flowing through the olive oil is much slower than that entering the soap. This is the reason for the displacement and angle change between the two images photographed. What can be seen in this calculation is that the higher the index of refraction, the slower the light waves pass through the medium. This is an interesting concept considering the difference in color of the two mediums. Without much background, one might think that the darker the fluid, the slower the light passes through. In this case, that is not correct. If this image were to be retaken, I would focus more on the angle of refraction from both the light

and pen. The angle of the pen has a drastic effect on what is seen past the line of medium change. Also there are other mediums with much different indexes of refraction that would be interesting to see.

Photographic Technique

Field of View: 2” wide by 1.5” tall

Distance: This was about 4”

Lens Focal Length: 4.15

Camera: iPhone 5s

Aperture: 2.27

Shutter Speed: 1/60

ISO: 50

Image Size: 1440x864

Post Processing: Some curves to whiten the background and match the images together

References:

[1] https://oilpalmblog.wordpress.com/2014/08/31/quality-and-identity-characteristics-of-palm-oil-part-3-identity-characteristics-physical/

[2] http://micro.magnet.fsu.edu/optics/lightandcolor/refraction.html

[3] http://www.physicsclassroom.com/class/refrn/Lesson-2/Snell-s-Law