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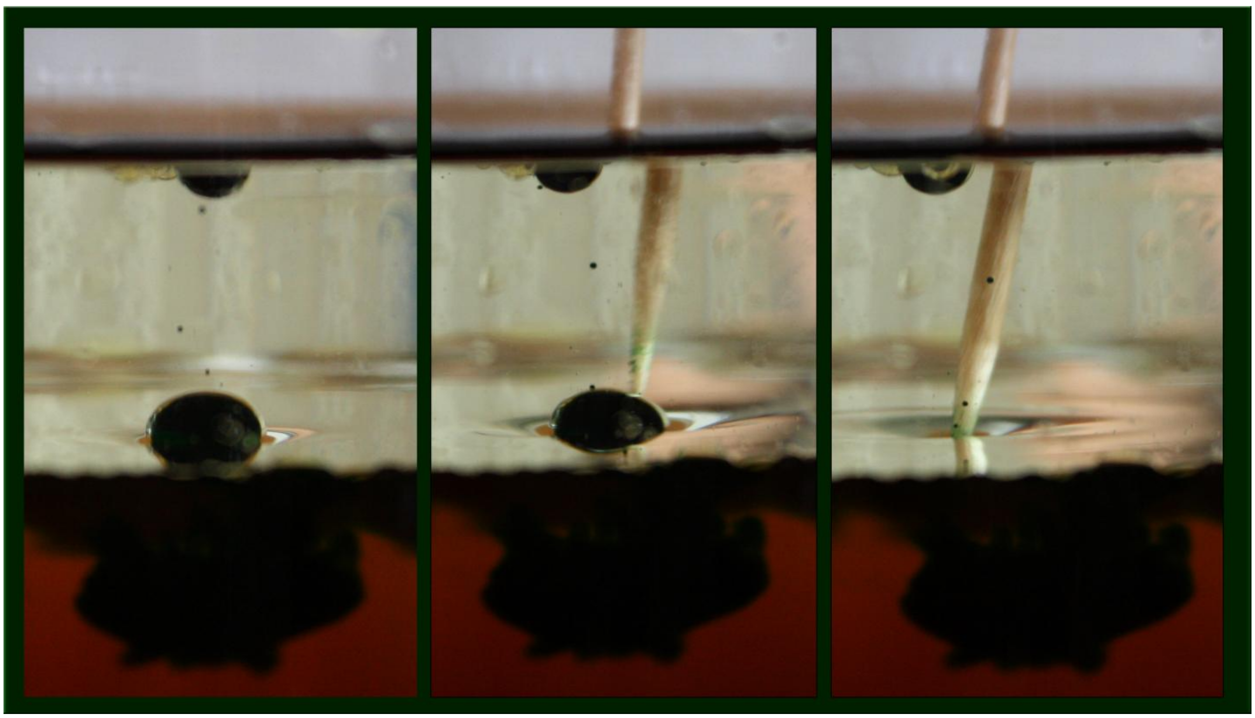
MCEN 4228
Group Project 1

Image Taken: March 16th, 2010 3:10PM



There are a variety of fluids that are present in the common kitchen that can be used to demonstrate different fluid phenomena. This photo progression of food coloring drops was taken for the first group project. The intent of the image was to see what the effect of food coloring droplets in different fluids, subjected to a variety of disturbances.

A clear glass beaker was used, along with mint syrup, water, red and blue food coloring, peanut oil and a toothpick. A schematic diagram is shown below in Figure 1 to represent the set up. The beaker was first filled with an inch of mint syrup, the densest fluid of them all. It was then filled with 2 inches of red water, that was previously mixed with two drops of red food coloring, followed by an inch of peanut oil. Multiple blue food coloring droplets were added to the top layer of the oil to see the effect of the different fluids in the beaker. The droplet stayed in place for a minute, and then would drop to the next layer of liquid. A toothpick was poked through the peanut oil to pop the food coloring droplet on the top layer of the water, which made it disperse into the red water.

Comparing densities, the fluid layers made sense with the density increasing from top to bottom. The fluid densities are listed below:

- Water – 998.2 kg/m^3 [2]
- Food coloring – 998.2 kg/m^3
- Peanut oil – 912 kg/m^3 [3]
- Syrup – 1333 kg/m^3 [4]

The droplet of food coloring on top of the water made an indentation on the surface of the water. This was due to the cohesive forces between the liquid molecules which cause surface tension on the top layer of the water. The food coloring droplet was ~2mm in diameter. Once the toothpick pierced the droplet, it dispersed into the water. Once the legs of the dye reached the top layer of the syrup, it stopped moving.

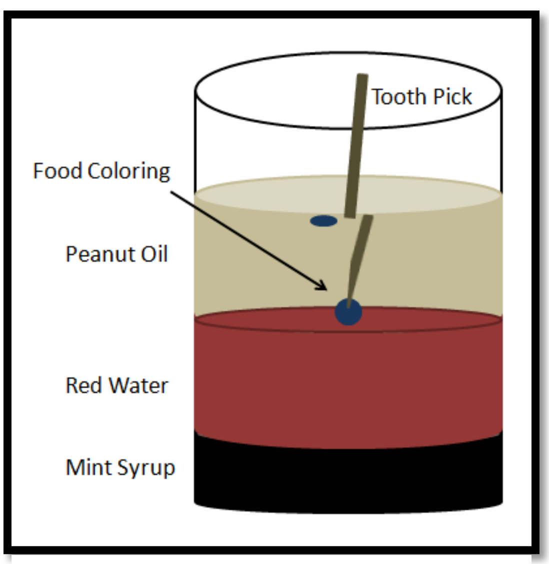


Figure 1 – Picture Set Up

Within the photo, the toothpick appears to be broken, but it is actually due to the refraction of light. The light from the toothpick is refracted as it passes from the oil to the air, causing it to be displaced. Since the surface of the glass beaker is curved, the toothpick is enlarged by the magnifying effects. When light travels through transparent materials, the light velocity changes according to the index of refraction of the material. The index of refraction is a measurement of how much the speed is slowed within a material [1].

$$i = c/cm$$
$$c = speed\ of\ light$$
$$cm = speed\ of\ light\ in\ material$$

The index of refraction for air, oil and glass is 1, 1.4, and 1.7, respectively. Light is a wave which travels at 186,000 miles/sec in a vacuum. This speed slows down in other materials due to the electric fields in the material.

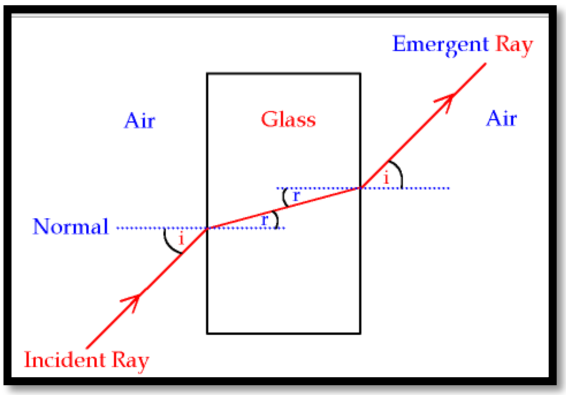


Figure 2 - Refraction

The only visualization technique that was used to create this photo was drops of food coloring, and it was taken inside within a 500mL glass beaker. The three images show a time resolution of the varying position and composition of the droplet. The flash did not go off; the lighting source was the natural light through the window.

The final photo dimensions were 4084 by 2316 pixels, with 72 pixels/in resolution. This correlates to X and Y dimensions of 56.72 and 32.17 inches. The photos were taken with a Canon EOS Digital Rebel Xsi at a shutter speed of 1/25 sec. The F-stop and aperture values were both f/5.6. The ISO setting was 800 and the focal length was 55mm. Photoshop was used to crop the photos relative to each other to get a nice progression. The contrast and the saturation were also increased within Photoshop.

The distance from the object was 2.4 inches, or 0.2 ft. The horizontal image dimension was 56.72 in or 4.73 ft. The vertical image dimension was 32.17 in or 2.68 ft. The lens was 55 mm or 0.18 ft.

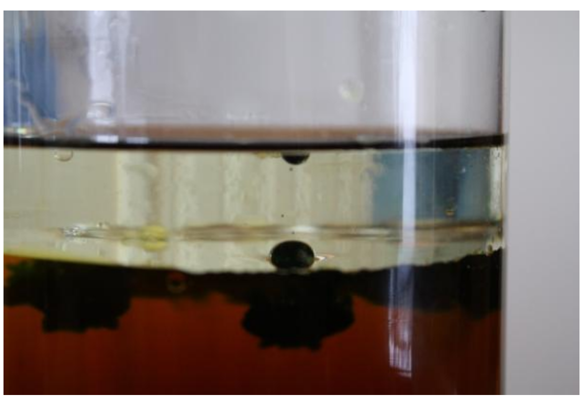
Horizontal field of view:

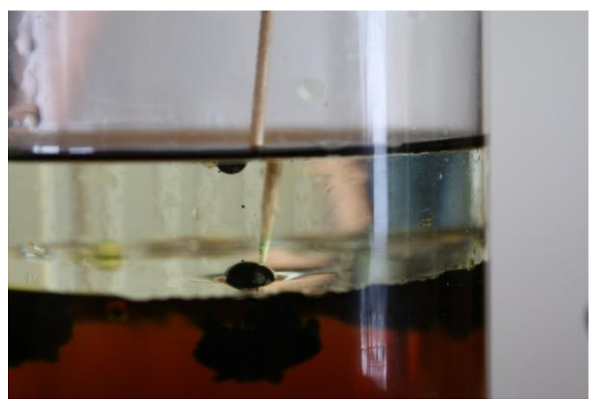
$$HFOV = d * \frac{i}{f} = 0.2 * \frac{4.73}{0.18} = 5.25ft$$
$$d = object\ distance$$
$$i = image\ dimension$$
$$f = film\ distance$$

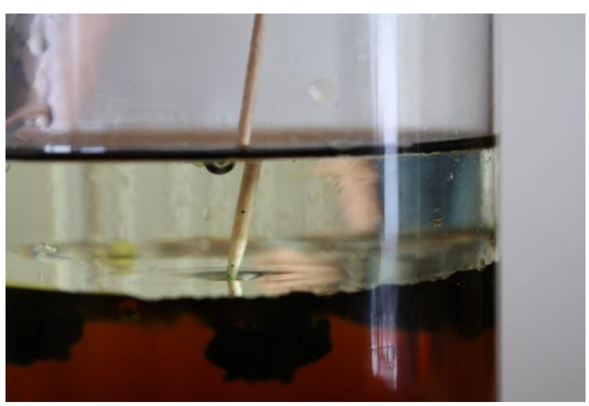
Vertical field of view:

$$VFOV = d * \frac{i}{f} = 0.2 * \frac{2.68}{0.18} = 2.98ft$$
$$d = object\ distance$$
$$i = image\ dimension$$
$$f = film\ distance$$

The image revealed a few basic fluid phenomena. The droplet on top of the water bent the fluid around it, showing the effects of surface tension. The difference in fluids caused the toothpick to look distorted, revealing refraction. I liked the progression of the food coloring droplet flowing within the different fluid layers, the details were clearly seen. The flow physics were easily seen, even though the set up is hard to interpret. The photo was in focus, despite the grainy effect that the bottom layer gave. The toothpick helped to show the scale of the image. I'm unsure as to why the focus seems off in the image, and I would alter the colors next time to be a little more pleasing to the eye. To improve this photo, more photos could be captured to increase the time resolution. Also, the fluid physics within the water didn't change, since a droplet had previously dispersed into it before this droplet broke. It would be interesting to have this be the only drop breaking into the water.







References

1. "Light Refraction." *Id.mind.net*. Web. 16 Mar. 2010. <http://id.mind.net/~zona/mstm/physics/light/rayOptics/refraction/refraction1.html>.
2. "Mass, Weight, Density or Specific Gravity of Water at Various Temperatures." *Metric Conversion Tables to or from Imperial Measurements The SI System for Metric Conversion*. Web. 17 Mar. 2010. <http://www.simetric.co.uk/si_water.htm>.
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