GET WET

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Flow Visualization
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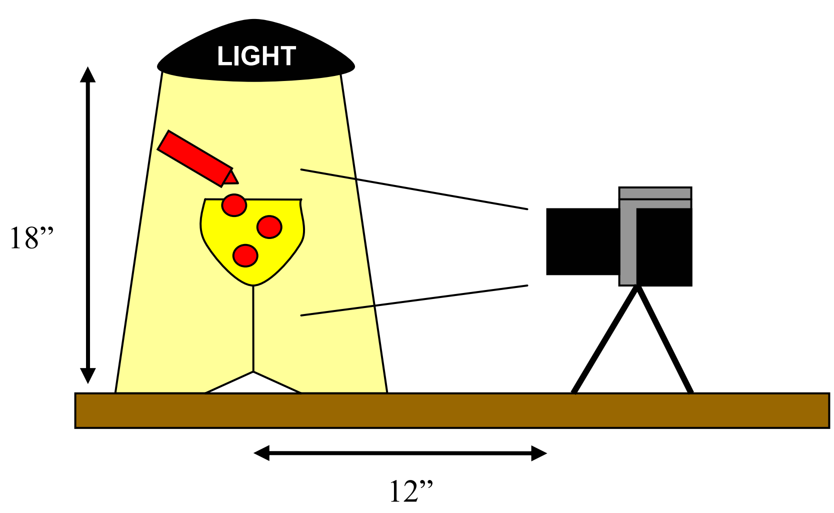
Introduction

For the initial 'Get Wet' assignment, I chose to analyze liquid water in and its interface with vegetable oil. The goal of the experiment was to identify the physical shape of the liquid water structure when immersed in vegetable oil and to also analyze the shape's motion. Ideally, I would like to show that water will remain separate from the oil and behave as a rigid body falling due to gravity.

Apparatus

The apparatus of the experiment (See Figure A) includes basic household items. A crystal wine glass was used as the container which was filled with eight to twelve ounces of vegetable soybean oil. Chilled water was combined one-to-one with red dye, which is essentially water and propylene glycol. The camera was placed twelve inches in front of the glass in order to closely view what was to happen. The wine glass was then illuminated by a 20W Halogen light bulb roughly eighteen inches above the base surface.

Figure A - Apparatus



Description

The fixed body of oil (Reynolds number Re=0) will allow the colored liquid water to behave purely based on surface tension, viscosity, and gravity. Theoretically, I would expect the water to make a fast transition to the bottom of the glass, allowing the more buoyant vegetable oil to stay at the surface. This is due to the soybean oil's lower density of 0.926 kg/L (Engineer's Edge, 2000) and water's higher density of 0.997 kg/L (Engineer's Edge, 2000) as well as the differences in viscosity. The velocity of the drop once it is in the vegetable oil will increase from zero at the surface to a set terminal velocity. This velocity develops from the higher density of the water that creates a downward force in the oil. The force then creates a shear stress on the surface of the vegetable oil. This force is proportional to the rate of shearing within the water and vegetable oil. This rate of shearing is inversely related to the viscosity of the fluid. Since the viscosity of the vegetable oil is 75 centistrokes (Engineer's Edge, 2000) and the viscosity of the water is 0.802 centistrokes (Engineer's Edge, 2000), it is clear that the rate of shearing will be higher for the water than for the vegetable oil. (Fundamentals of Fluid Mechanics, 2006)

Image Specifications

The field of view of the final image is three inches wide by five inches tall, taken from approximately twelve inches in front of the center of the wine glass. The focal length of the lens was 85mm. This is the maximum focal length of the wide angle 17mm-85mm macro lens. The image was taken using a eight mega pixel Canon Rebel XT with the flash turned off. The shutter speed of the image was 1/100 seconds and the aperture value was 5.6. The ISO speed was set at the camera's standard value of 400. The relatively slower shutter speed produced a clearer image and did not sacrifice any detail since the motion is particle motion is relatively slow. The final image was manipulated slightly using Canon's Digital Image Professional basic image editing software. The color levels of the photo were slightly adjusted and the brightness was slightly increased. The dropper was cropped out of the photo to focus on the wine glass itself.

Figure B – Original & Final Picture

Conclusions

This image revealed the almost peaceful interaction between these two liquids. The red drops of water were dropped into the oil body where they remained at the surface for a few seconds, maintaining their original spherical shapes. At this point, the negative buoyant forces of the water drops pushed them through the oil where they slowly fell to the bottom of the glass at roughly one centimeter per second. The surface tension of the water maintained the spherical shape of the drops during the entire fall. Once the drops reached the bottom, they again maintained their original shape, only a few of which combined from the pressure of the other drops overcoming their own surface tension.

REFERENCES:

1. **Engineer's Edge**. http://www.engineersedge.com/fluid_flow/fluid_data.htm. Copyright 2000.

2. **Fundamentals of Fluid Mechanics, 5th Edition.** Bruce R. Munson, Donald F. Young, Theodore H. Okiishi. John Wiley & Sons, Inc. 2006. Reference: Viscosity