

CU Boulder

Flow Visualization

Get Wet



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MCEN 4151: Flow Visualization

Introduction

The intent of this experiment is to develop an understanding of photographic techniques while exploring visualization of different fluid phenomena. This report discusses the experimental approach, the physics behind, and the visualization and photographic techniques of blue food coloring in almond milk, as depicted on the front page of this report. The idea behind this image is to explore the tried and true “dye in milk” experiment through a different avenue that creates a unique image that stands by itself.

Experimental Approach

With this photographic intent, a different experiment is devised. In order to achieve a visually stunning image, natural lightning and heavily contrasting objects are used. The photo is taken on the railing of an east facing second story balcony. The sunlight is filtered through the leaves of a tall American Elm tree at about three o’clock pm in mid September. The base fluid is “Almond Breeze” brand almond milk poured into a matte black ceramic tea cup to increase the contrast around the focus point of the fluid. A single drop of blue food coloring, bought at King Soopers, is gently stirred by the tip of a eucalyptus toothpick. A diagram of this setup is presented below.

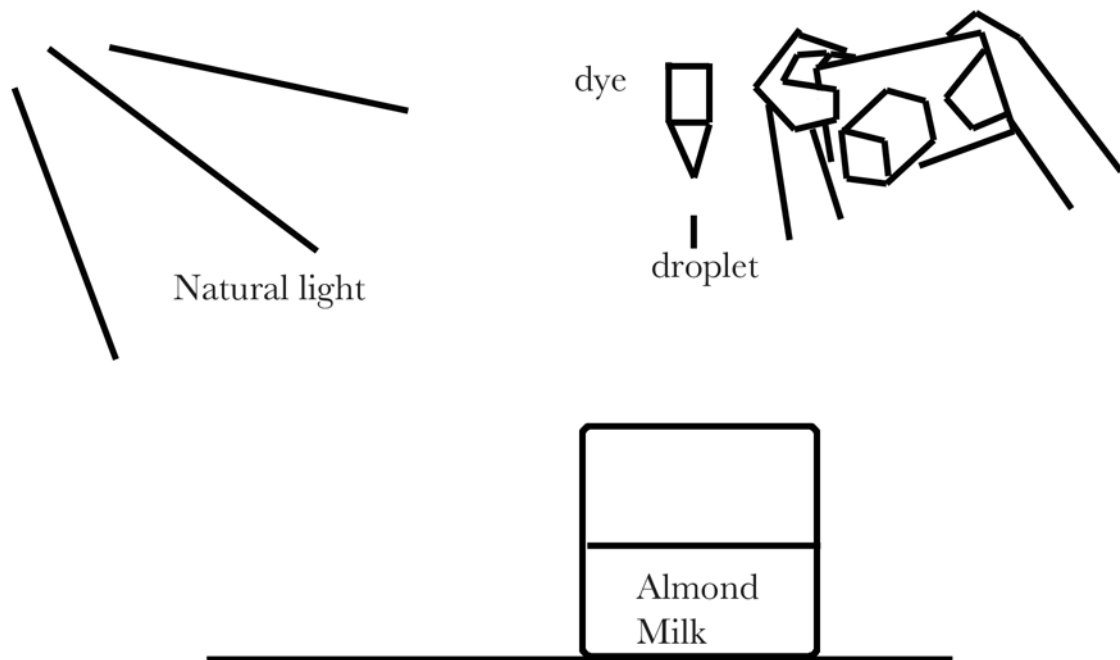


Figure 1: Experimental Setup

Description of Flow Physics

There are two main fluid phenomena occurring in the image, effects of surface tension and wake mixing. Surface tension is responsible for the food coloring floating on top of the almond milk. This is due to varying densities between the two

liquids, the almond milk being the denser of the two liquids. This surface tension also causes the two liquids to not readily mix with each other, resulting in the darker bands of blue (higher concentrations) in the image. This phenomena is also called the Marangoni effect. This effect describes the transfer of mass along gradients of surface tension, much like the areas of higher concentration described above. This gradient is divided between the almond milk, the alcohol in the food dye, and the rest of the ingredients of food dye. [1]

The other phenomena present, wake mixing, is responsible for the shaping and mixing of the blue dye in the milk. The motion of the toothpick through the milk causes localized areas of higher acceleration through the liquid. Since the toothpick is also dragged through the dye mixing of the dye and milk occurs in the wake of the toothpick. The specific motion of the toothpick is a dual figure eight pattern. One figure eight in the horizontal direction of the image and one incomplete figure eight in the vertical direction. Both eights share the same relative center point.

Photography Technique

A Nikon D3000 DSLR camera is used to capture the image. Some experimentation to find the proper ISO, shutter speed, and aperture setting is performed before the dye is added to the milk. The main focus of the image is to preserve the contrast between the surrounding objects and the milk. The values ended up being a F-stop of f/5.6 and a shutter speed of 1/40s were found to work best. The ISO was left in an automatic setting for the camera, which retroactively was found to be 1600 from the .xmp file. The focal length is 32 mm.

Post Processing

The image is edited from the original using Adobe Photoshop Elements. No cropping is performed, both the original and edited image measure 3872×2592 pixels. Most notably different is the increase of contrast and slight increase of brightness to the image. Then, using the curve tool, the blue channel is slightly increased to make the blue dye stand out more. The figures below show a side-by-side comparison of the image before and after processing.



Figure 2: Original image



Figure 3: Edited image

Conclusion

Using the sample size of the Fall 2015 Flow Visualization class at CU-Boulder, the goal of making a different image that stands out, while also using simplicity as the key, is achieved. The fluid phenomena present are clearly portrayed and the aesthetic of the image resulting is quite pleasant. Using blue as the dye color seemed to work well, as it draws the eye in an otherwise natural toned image. Doing this experiment again, I would like to use perspective to cut out the dirt portion in the background and only use the asphalt. I would also move the focus point more towards the fluid and less towards the center of the image.

Reference:

[1]: Surface Tension Lecture 4: Marangoni Flows. (n.d.). Massachusetts Institute of Technology Retrieved November 5, 2015, from <http://web.mit.edu/1.63/www/Lec-notes/Surfacetension/Lecture4.pdf>