Painting with Food Coloring

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MCEN 5151

Food Coloring in Milk

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Introduction

The purpose of this photo was to practice photographing fluid flow and develop an understanding of the various challenges with flow visualization. The assignment also provided an opportunity to get familiar with using a camera with manual adjustment capabilities. For this introductory *Get Wet* assignment a simple vortex was captured using food coloring and milk.

Fluid Physics

Flow Description:

The photo captures a vortex forming in a bowl of milk after a Q-tip is dragged across the surface. Two colors of food coloring, yellow and green, were introduced to the bowl of milk just prior to the creation of the vortex. As a result the food coloring followed the laminar flow lines of the milk and generated two aesthetically pleasing counter-rotating spirals.

Apparatus:

A fairly simple apparatus was used to capture this photo. A light box constructed out of foam core to diffuse the 100 watt light source in order to provide even soft lighting. Milk was then poured into a standard cereal bowl and a couple drops of Kroger brand food coloring was added. Finally, in order to disturb the calm pool of milk a Q-tip was dragged across the surface in a swift manner. In doing so a localized current and wake was produced, which generated the vortices seen in the picture. Below in Figure 1 is a schematic of the setup.

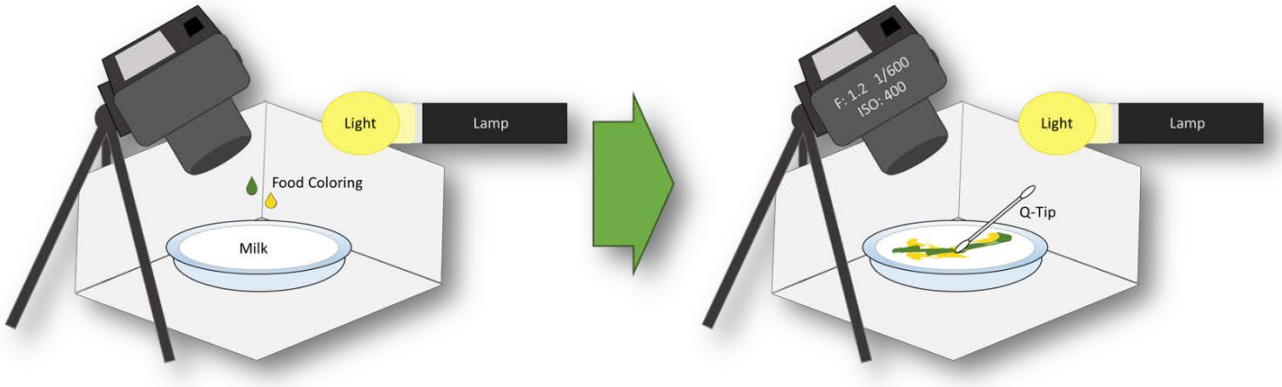

Figure 1: Picture setup consisting of a light box, camera on a tripod and a bowl of milk

Lighting:

The 100W bulb was situated approximately a foot above the base in order to provide an ample amount of light.

Scale:

The cereal bowl was approximately 5 inches in diameter, and the camera was placed roughly 6inches above the surface. The total area of the photograph is roughly 9in^2

Fluid Phenomenon:

The fluid phenomenon that was captured was the creation of vortices due to the presence of a current. When the Q-tip was dragged swiftly across the surface it pulled the milk in the direction that it was moving via friction; friction between the Q-tip and the milk as well as the friction forces associated with the viscosity of the milk.[1] The Q-tip also created a pressure difference in

the bowl of milk when it created a wake or region of empty space behind it. A wake is a low-pressure area, and as a result the surrounding higher-pressure milk was cause to flow in the opposite direction of the Q-tip triggering a circular flow pattern.[2] Figure 2 is a good illustration of the phenomenon being described.

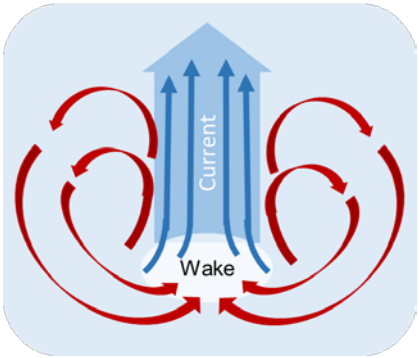

Figure 2: Diagram of how vortices form

This vortex phenomenon is commonly found in streams and rivers when the current flows around a rock or obstacle that disturbs the flow.[3] These vortices are usually called an eddy and are utilized by swimmers and boats to get out of the current of a river in order to head up stream easier or stay in one place. However, in our case instead of a rock or obstacle creating the vortices a jet created them. This vortex formation can be seen as Figure 76 in *An Album of Fluid Motion*.[4]

It should be noted that the flow of the food coloring in the vortices appears to be very laminar. One can clearly identify how the two different colors of food coloring were pulled by up and around the spiral vortex with minimal mixing. This laminar flow was expected because the speeds at which the fluid was moving was very slow, which drove the Reynolds number towards zero well below the critical Reynolds number and within the laminar range. Below is the actual calculation of the Reynolds number for this picture.

$$Re = \frac{VD}{v} = \frac{\left(0.01\frac{m}{s}\right)(0.005m)}{1.13\ x\ 10^{-6}\ \frac{m^2}{s}} = 40$$

In With a Reynolds number around 40 the flow is well within the laminar range, which is expected and illustrated in the picture.

Visualization Technique

In order to capture the vortices created by current forces, food coloring was used to dye the milk and provide contrast to against the white milk background. A Q-Tip was used to generate a current in the milk to produce the resulting vortices.

Materials & Process:

Milk and food coloring were used for this photo for a number of reasons. First, they are commonly found in one's kitchen, they are of similar density, and milk provides a nice white opaque surface to seemingly paint on with food coloring. Another reason milk is a great medium to use for flow visualization is because the fats in milk slow the diffusion of dyes, which allow for distinct visual laminar lines to develop.[5]

After the food coloring was gently dropped into the bowl of milk a Q-tip was used to generate a localized current within the bowl. This was done by dragging the Q-tip across the surface of the milk starting at the location of food coloring. In doing so the food coloring was pulled into the flow and followed the milk into the resulting vortices that were created.

Photographic Technique

In order to take a nice picture the whole setup was conducted within a light box constructed out of foam core and lit using a 100W filament light bulb. The camera that was used was a JVC camcorder, which was mounted on a tripod directly above the bowl approximately 6 in from the surface.

Camera Settings:

The setup was very well lit, so a relatively fast shutter speed of 1/500 in order to reduce motion blur. An F stop number of 1.4, and an ISO of 400 were used. These setting ensured that there was no motion blur and that the picture would not be saturated in anyway.

Post Processing:

In Figure 3 you can see the original picture and then the picture after some post processing. The post processing was conducted in Adobe Photoshop CS5 and primarily increased the brightness, provided some cropping and eliminated the side of the bowl. The post process picture appears a great deal brighter than the original picture at that was done in order to give the picture a more painted feeling.

Figure 3: Original photo (left) and post processing photo

Reflection

This image did a good job in capturing a simple vortex, and I find its simplicity very beautiful. I personally like the color choices in this photograph; the yellow and green provide a nice contrast against each other as well for a variety of color depth within themselves. I particularly enjoy the depth of color produced from the yellow food coloring; it appears more orange in thicker concentrations. If I was to improve this photograph I would conduct this photograph on a larger scale. This way the vortices could develop a little more, and the laminar flow would be more apparent.

Bibliography

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3. "Where to Fish: Rivers and Streams." - *NYS Dept. of Environmental Conservation*. N.p., n.d. Web. 25 Feb. 2014.

4. Dyke, Milton Van. *An Album of Fluid Motion*. Stanford, CA: Parabolic, 1982. Print.

5. Smits, Alexander J. *Flow Visualization: Techniques and Examples*. London: Imperial College, 2012. Print.