Get Wet 2016

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Flow Visualization

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Introduction:

The purpose of the Get Wet assignment was to "get our feet wet" and have everyone take a more artistic approach to fluid flow phenomenon. For my image I wanted to try and capture the mesmerizing flow that occurs when ice is added to scotch as a result of the forced convection of two fluids in a solution having different densities.

Flow Apparatus and Visualization Techniques:

In order to avoid wasting scotch during the repeated attempts made to get this image just so, rubbing alcohol and water replaced the scotch. The water and rubbing alcohol (97% isopropyl alcohol) were mixed in a roughly 1:1 ratio. To facilitate the convection a spherical ice cube, approximately 2" in diameter was used. To help visualize the convective flow red food dye was used. Both fluids in the solution and the red food dye were initially at room temp (~22 Celsius). Light was provided by minimal sunlight filtering in from windows off to the left, as well as a 60W bulb above and to the left of the apparatus.

The flow in this setup is caused convection driven by having a cold ice cube cooling the warmer liquid causing it to become more dense and sink, and at the same time the varying densities of the fluids involved results in some fascinating swirling as the fluids fall to the bottom of the glass. The Reynolds number is given by (U*D)/v. With U approximately at 0.75 m/s, a D of 0.09m, and an average kinematic viscosity of 1.262 x 10^{-6} m^2/s. Resulting in a Reynolds number of approximately 53500. This high of a Reynolds number suggests that the flow is turbulent, which can be seen in the small scale eddying occurring in the flow along with the large scale movement. Also the flow moved approximately 0.025m during the time the image was captured.

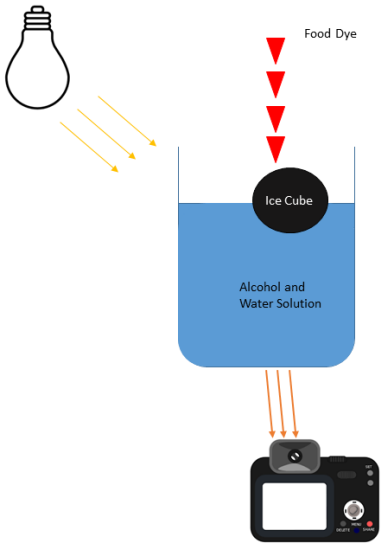

Figure 1: Flow Apparatus Set Up

Photographic Technique:

The photo was obtained using a Canon EOS 50D with a 28-135mm lens. A tripod was not used but the camera was instead placed on the floor to be in line with the glass that was also on the floor. Lighting was obtained via a 60 W lamp placed above and to the left of the image, with some sunlight filtering in from the left as well. In order to obtain as many images of the flow developing as possible the camera was set to sport mode, which allows shots to be taken in rapid succession via a constant press of the shutter button. However, this resulted in the camera choosing the aperture, shutter speed, and ISO automatically, and as a result the ISO was quite high to account for the less powerful light provided from the 60W incandescent bulb as compared to other lighting solutions. The camera was approximately 36 inches from the glass. In order to minimize background disturbances a black backdrop was used.

Camera	Canon EOS 50D
Lens	28-135mm 1:3.5-5.6 IS
Original Image Size	4752 x 3168
Final Image Size	1588 x 1722
Focal Length	135mm
Aperture	f/5.6
ISO	1600
Shutter Speed	1/30
Field of View	Approx. 6” x 4”
Exposure Bias	0 step

For post processing this image was edited with GIMP. The image was first cropped to try and cut out as much of the background and the non-dyed flow as possible. Then the only other alteration was significant alteration of the contrast and color curves of the image to deepen the reds and really help the flows to pop.

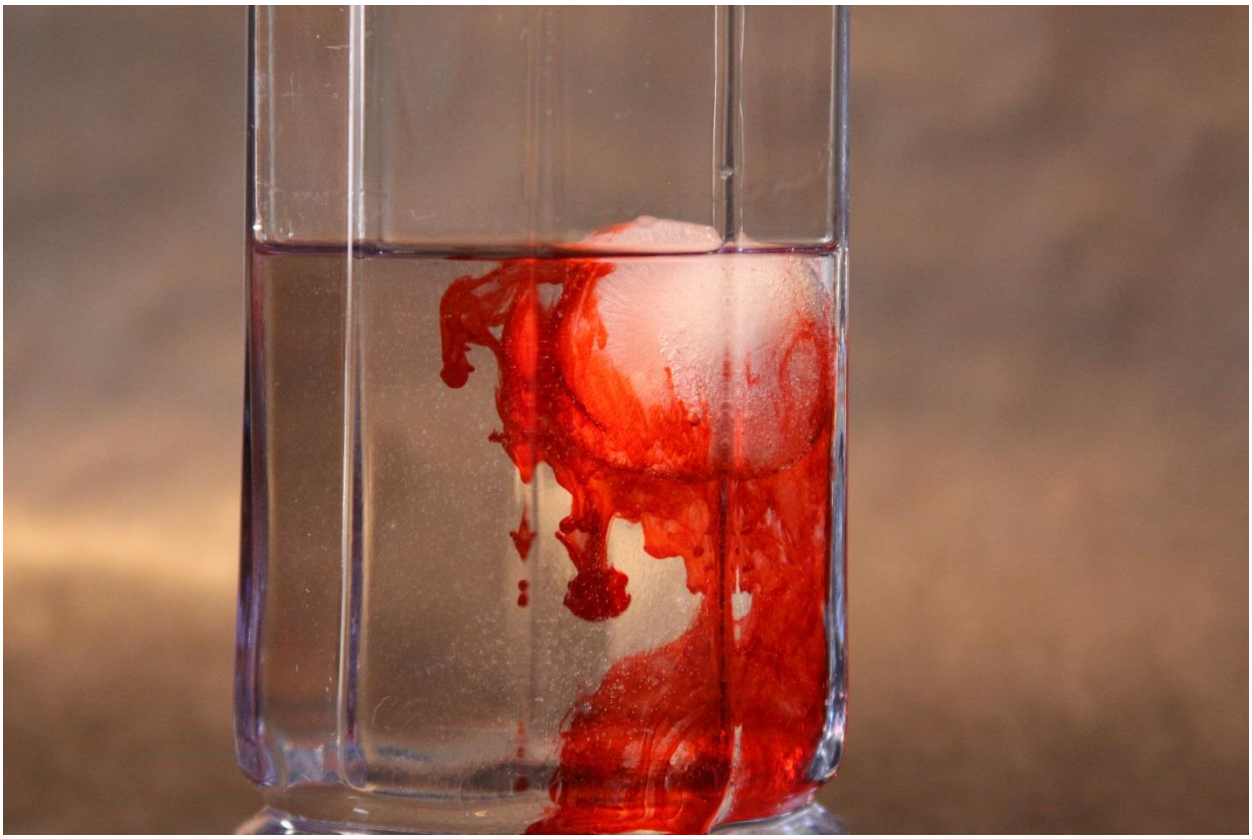

Figure 2: Original Image

Image Reveals:

This image reveals that there are some interesting flow shapes that can occur from the mixing of two fluids of different densities in a convection driven flow. The fluid physics are shown reasonably well, however, the solution of alcohol and water manages to make the image appear more blurry in certain areas. In the future I would like to improve and develop upon this apparatus by using a glass with no distracting edges, using a white background instead of a black, providing more light so shutter speed can be increased and ISO dropped, allowing more time from when the ice was added to when the dye was added so that there would be less bubbles in the flow.