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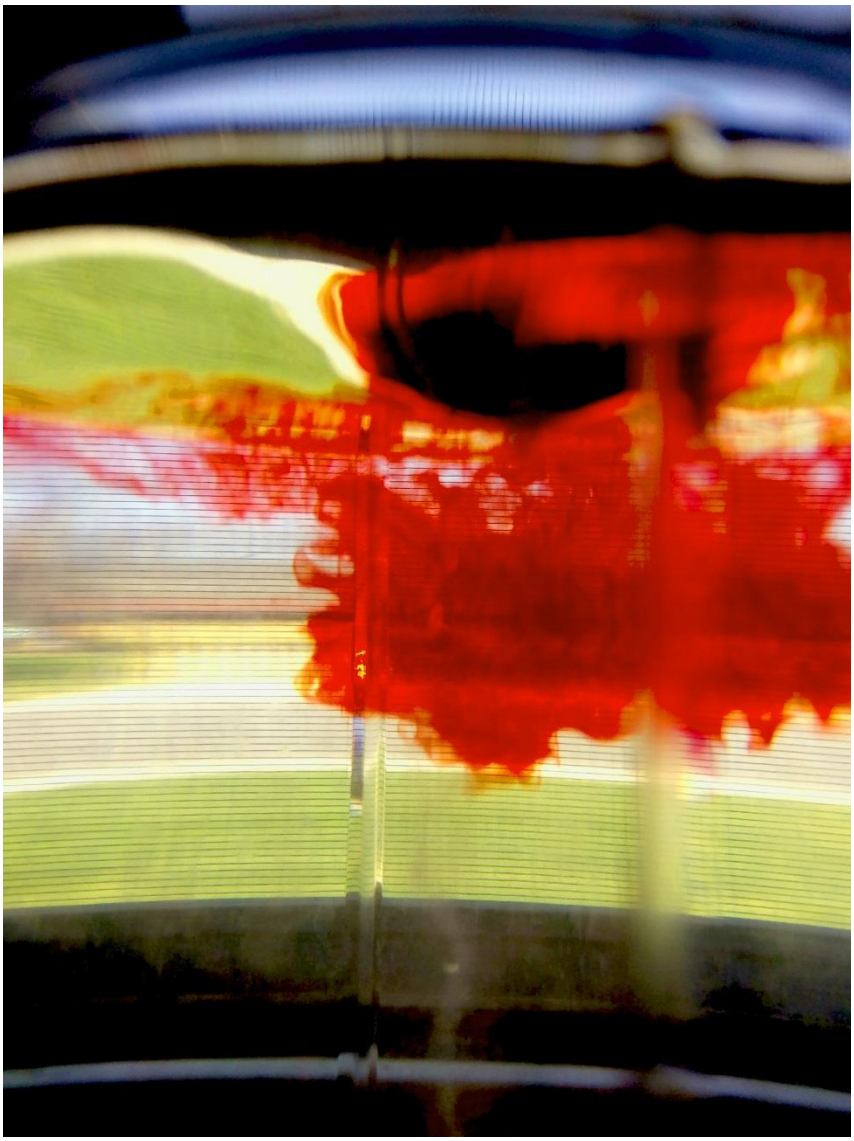
FILM 4200

Team Third Report – Propylene Glycol in a Vortex



Purpose of the image

For our group's Team Third assignment, I decided to create my own interpretation of the theme my team chose, which was photographing dye flows in water. This photograph shows how I was best able to represent the swirling motion of the flow through the addition of dye in a saltwater solution after creating a vortex motion in the solution. Working in conjunction with the placement of the sunny background and use of a red and cloudy dye, I felt that I was able to accurately display the dynamics of flow in a vortex, demonstrating how flow is affected by the swirling motion.

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Flow demonstrated

The image shown above represents the effects of the Kelvin-Helmholtz instability, and the effects of vortices on the flow. By creating a vortex flow in a circular container, different velocities cause shearing effects due to difference in flow speeds forming concentric circles from the center to the periphery. These concentric circles are best described as irrotational vortices, where the tangent motion of the particle velocity is dictated by the formula

$$u_\theta = \frac{\Gamma}{2\pi r}$$

The Γ variable is the circulation velocity of contours that enclose the vortex axis once.[1]

In the given images, the water contains 73 ml of kosher salt dissolved in 3.78 liters of hot water of 48 degrees Celsius. The addition of kosher salt increases the viscosity of the water, and allows for the pooling effect of propylene glycol-based red food dye visible near the center of the vortex pattern. The difference between the velocity of the inner contours and outer contours is great enough to cause the aforementioned Kelvin-Helmholtz instability[2] in the red food dye areas, and pooling of dye can be seen near the center of the formation.

Additionally, the water's refractive index creates interesting bending effects of light around the edges of the container.

Materials Used

Photo equipment used to capture this flow image consists of an HTC 10 phone camera with a 12 megapixel 1/2.3" sensor, a 4 liter cylindrical container made of acrylic, a window for backlighting, and Kroger brand propylene glycol-based red food dye. I experimented with different velocities of vortex flow and placement of the red food dye. The process involved replacing dyed water with fresh water of the same temperature, dissolving 73 ml of kosher salt in the mixture, stirring the mixture and placing the drop of food dye near the outermost contour of the vortex. The water mixture was dumped out and re-created 5 times in total.

[1] "Vortex." Wikipedia, Wikimedia Foundation, 27 Apr. 2018, en.wikipedia.org/wiki/Vortex
[2] "Kelvin-Helmholtz Instability." Hydraulique et Mécanique des Fluides. 27 Apr. 2018, "http://hmf.enseeiht.fr/travaux/CD0001/travaux/optmfn/hi/01pa/hyb72/kh/kh_theo.htm

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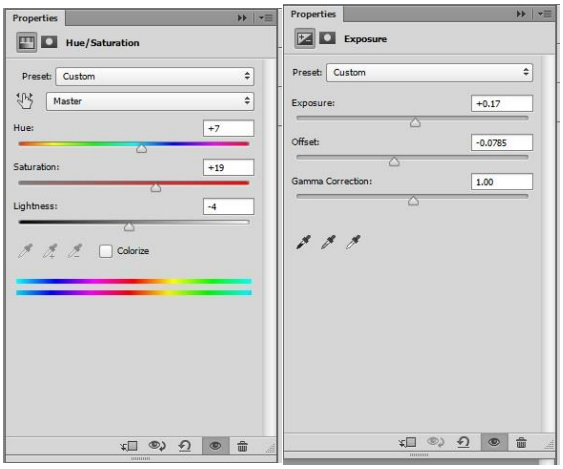
Photo technique

Through use of the strong sunlit backlighting in the picture, I made use of the exposure to capture the flow in a well-lit manner that shows the nature of the flow from all angles. The image also features a large depth of field, shooting at a fixed aperture of f1.8 and a shutter speed of 1/372. By using an ISO setting of 100, the exposure provided for detailed highlights and shadows without any visible sign of digital clipping. Finally, I tweaked the Hue/Saturation and Exposure in Photoshop using the following values:



Honorable mention photos: