Colored Water

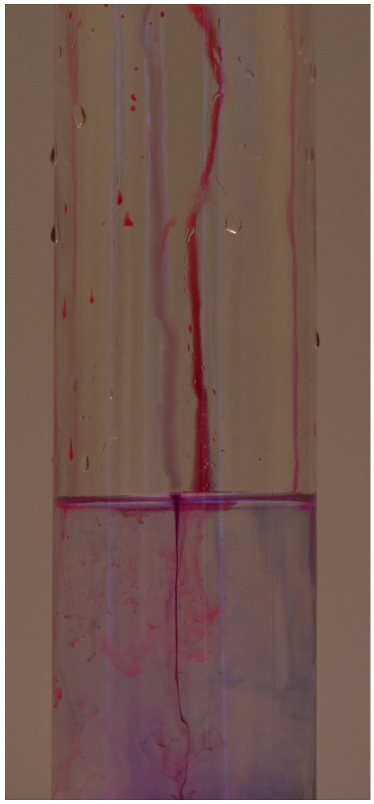

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Image 2 Assignment

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MCEN 4151-001

I. Introduction

This image was created for the second image or video assignment for the Flow Visualization course. The intent of the image was to capture the flow of water by utilizing watercolor paints for contrast against a glass vase. Also, the image shows flow of water dripping on the edge of a glass as well as flow into stagnant water.

II. Flow

The flow apparatus used was a wet paint brush and a tall glass vase filled partially with water. As seen in Figure 1 the paint brush mixed water into a watercolor palette and then dripped onto the insides of the vase. In the final image there is color in the water already due to previous experiments where watercolor paint was mixed into a teaspoon and then dropped into the water. The reddish colored water is the most recent color that was dripped into the vase. The total height of the vase , *h total*, is ten inches and the height of the water, *h1,* is four inches. The diameter of the vase used, *D Vase,* is 2.5 inches and the estimated diameter of a drip of water, *D Drop*, is .025 inches.

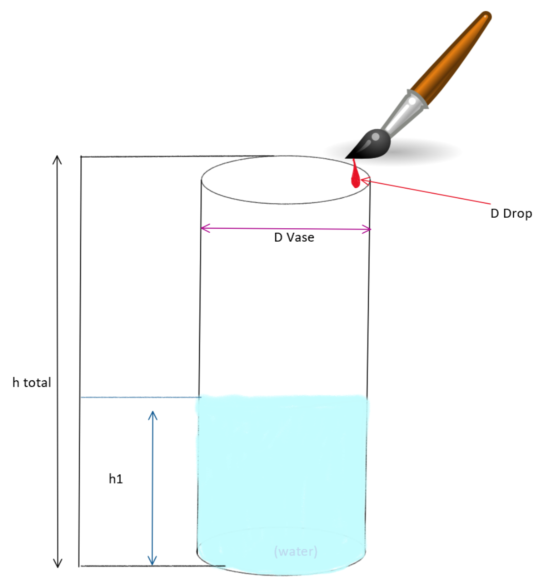

Figure 1. Flow apparatus set up.

In this flow setup to create the image the primary acting force on the liquid drops is gravity. Other forces that are present are friction and air resistance, but these are assumed to be very small, and the net force of all these forces combined is downward which drives the droplet motion down into the stagnant water. A visual representation of these forces can be seen in Figure 2 below. The larger arrow represents the relative largeness of gravity versus the other forces present.

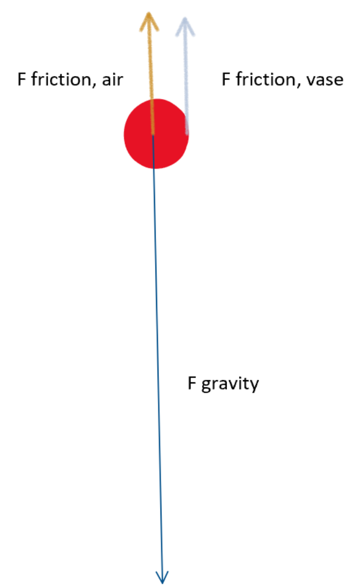

Figure 2. Free body diagram.

Property	Value	Units	Reference
Density (ρ)	1	g/cm^3	[1]
Dynamic Viscosity (μ)	.0009737	N s/m^2	[3]
Velocity (*U*)	.01	$\frac{m}{s}$	*Estimated*
Diameter (*D* Drop)	.025	*in*	*Estimated*

Table 1. Property values for water used for watercolor paint calculations.

Table 1 has values used in calculations to describe the flow. The properties used are for regular water at 70 degrees Fahrenheit because it is assumed the density and dynamic viscosity of watercolor liquid is approximately equal to the properties of water and the difference is insignificant. Also, the velocity is assumed to be constant throughout the flow.

Kinematic Viscosity $$v = \frac{\mu}{\rho}$$ Eq. 1

Reynolds Number $$Re = \frac{U*D}{v}$$ Eq. 2

Using Equation 1 and Equation 2 above the Reynolds number was calculated for the droplet using the assumptions and values of Table 1. Only two decimal places

$$v = \frac{.0009737\ N \frac{s}{m^2}}{1\ g/cm^3 * 10^3 \frac{kg/m^3}{g/cm^3}} \qquad v = 9.737 * 10^{-7} \frac{m^2}{s} \sim 9.7 * 10^{-7} \frac{m^2}{s}$$

$$Re = \frac{.01 \frac{m}{s} * .025\ in * .0254 \frac{m}{in}}{9.737 * 10^{-7} \frac{m^2}{s}} \qquad Re = 6.5215 \sim 6.5$$

The Reynolds number calculated for the flow of the water droplet before it hits the stagnant water is very low which indicates that it was experiencing laminar flow. Laminar is normal when there is slow, viscous flow through a channel [3], so the calculated Reynolds number is low most likely due to the compilation of assumptions used to do the calculations. For application purposes laminar flow means the fluid travels smoothly and in regular paths, as well as the fluid has constant velocity and pressure [3].

III. Visualization Technique

Watercolor paint was used to dye the water used as the flowing fluid. There was also water already in the vase that had clouds of watercolor paint within it from previous runs of the flow experiment. The watercolors were crayola and I used room temperature tap water. There was a large white poster board placed in front of a bathroom mirror. A stand was made so that the vase was placed above the sink.

The bathroom window blinds were shut as well as a shirt was attached to block out the sun that was creating glare on the glass vase. The bathroom light was on and the flash was turned off on the DSLR camera. This created a solid off white background to contrast with the colored water streams.

IV. Photographic Technique

While shooting the field of view was set to be most of the vase without catching the threading on the top or the platform the vase was resting on. This was kept consistent with the use of a tripod. The dimensions of the field of view is approximately 10 inches by 12 inches due to the inability to rotate the camera vertically on this specific tripod. The distance between the vase and the lens was about two feet. This allowed for an easy focus on the entire vase. The automatic focus settings were on, but the ISO settings were increased. A Nikon D3500 DSLR camera was used. The date and time stamp were also set to be displayed as I took these images.

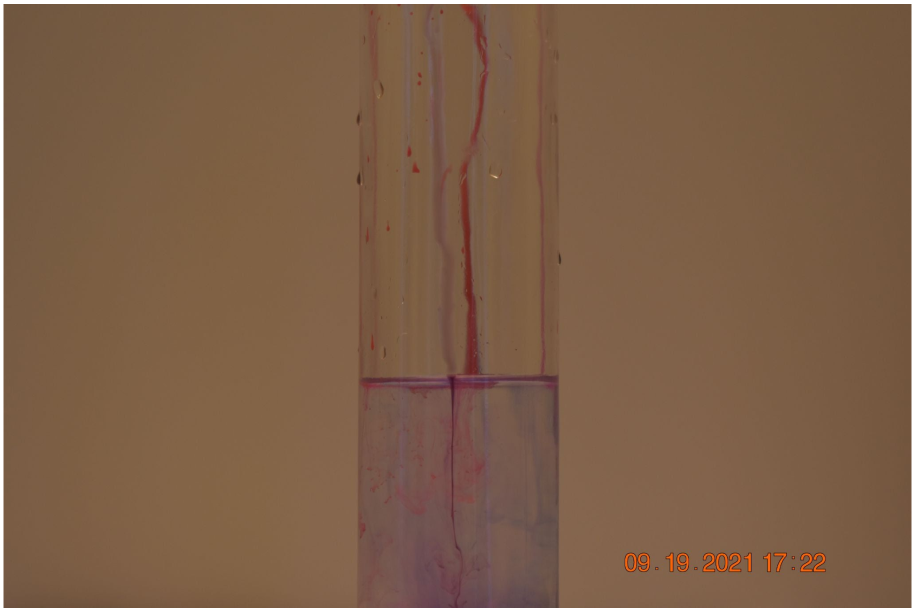

Figure 3. Original image.

In Figure 3 above the original image is shown. The image was cropped to be vertical orientation. This brings the focus directly to the vase. Darktable was used to post-process the image. In Figure 4 below you can see the editing history of the image. Most of these edits are small, micro adjustments. The color adjustments such as the input and output color profile, color zones, color correction, tone curve, and color calibration, were focused on increasing the contrast within the reds realm of colors as well as prevent the background from becoming too orange. The image was sharpened and the exposure was increased for a crisper view of the flow.

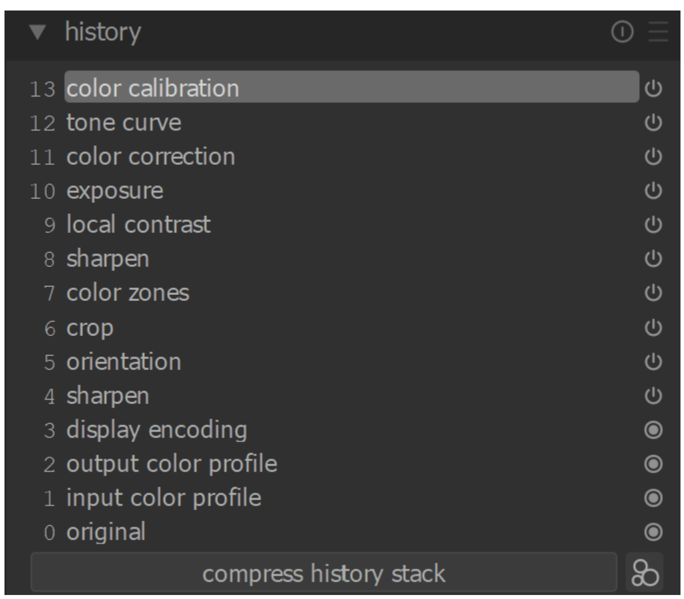

Figure 4. Darktable image editing history.

V. Final Thoughts

This image reveals the aesthetically pleasing flow of dripping water. The red colored streams of water running down the side of the vase into the more blue and purple stagnant water create a contrast of both motion and color. I like the flow captured, but I do wish the lighting in the bathroom was a little cooler instead of the warm color. The fluid physics are shown decently. It shows that the water streams do not go straight down the glass implying the flow is most likely not laminar, but also shows the stream of red flowing downward inside the stagnant water. This aspect shows that even the slightest difference in density will facilitate flow inside the water, as well as that the velocity of the water streams flowing into the blueish areas is not completely halted as soon as it reaches the water. A direction this could be taken would be to compare different dilutions of paint and see how far the stream reaches through the stagnant water, or how different kinds or brands of paint impact the path the water takes down the side of the glass.

VI. Works Cited

[1] "Density of Water G/cm3." *Amazing Converter* , https://amazingconverter.com/density-converter/density-of-water-g-cm3.

[2] "Laminar Flow." Encyclopædia Britannica, Encyclopædia Britannica, Inc., https://www.britannica.com/science/laminar-flow.

[3] "Water - Dynamic and Kinematic Viscosity." *Engineering ToolBox*, https://www.engineeringtoolbox.com/water-dynamic-kinematic-viscosity-d_596.html.