First Team Image Assignment

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Flow Visualization - Professor Jean Hertzberg
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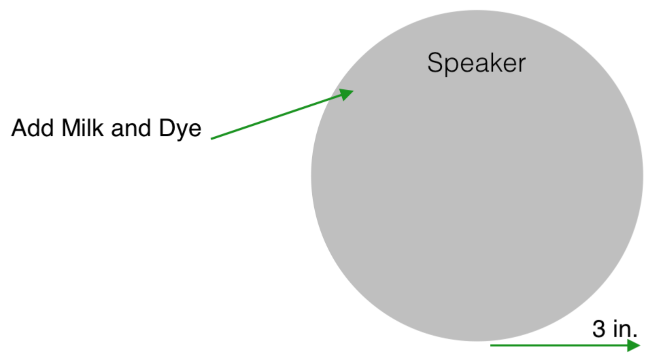
The image above represents a chaotic mixture of food dye in a solution that varies in density. The solution consisted of white viscous paint and milk. By mixing the two ingredients on top of a high frequency sub-woofer, the solution had inconsistencies in viscosity, which led to perplexing diffusion of dye in the final image. This was a first team project that focused on the diffusion of various colors after applying a high frequency to the base of the solution.

The flow apparatus used in the image consisted of a bowl-shaped sub-woofer that held the solution, with a layer of plastic wrap to protect the speaker. After pulsing the speaker at a high frequency for 10 seconds, the speaker was shut off, and observation was taken on the stagnant solution. The following depicts the setup for the experiment.



The camera view was looking down on the bowl shaped speaker after the mixing had settled. The flow seen is stagnant, and shows clear effects of mixing fluids of differing viscosities.The less dense fluid becomes pinched by the thicker fluid surrounding it in an elaborate manner. This leaves trails of color that represent physical properties of the fluid. The table below shows the densities of the separate fluids, which is the reason for the trails of color in the final image.

Fluid	Density
Dye	1005 kg/m^3
Milk	1033 kg/m^3
Paint	1198 kg/m^3

As seen above, the densities of the fluids vary and are the cause for some beautiful physics in the final image. By estimating the thickness of the color bands to be 0.01 meter, the Reynolds Number of the flow can be calculated. It is also estimated that the velocity of the flow under high frequency motion is .03m/s, using frame rate analysis methods.

t = *Time between pictures* = 1 *second*

d = *Distance of travel by fluid along horizontal* = .03m

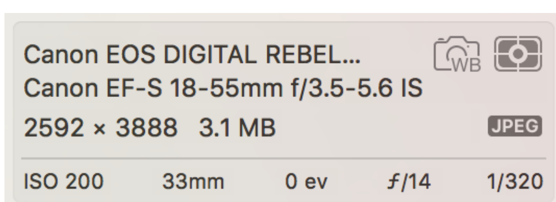
$U = d/t = .03 m/s$

v = 1.13 *cST* = $0.00000113 m^2/s$ (*Engineering Toolbox*, *Milk* @68 *degree*)

$$Re = \frac{UD}{v} = \frac{(0.03m/s)(.02m)}{(0.00000113m^2/s)} = 530.97 \quad \text{(Laminar Regime Re<1000)}$$

The Reynold's number indicates that the flow of milk (once poured) was within the laminar regime, which is why the diffusion occurred at a slow rate. The complexity of patterns increased as more milk was poured because the density of the fluid was continuously decreasing.

Environmental conditions during the experiment included ambient outdoor lighting from the sun (4:00 pm MST on 10/20/2016). There was no camera flash involved. The field of view was a width of approximately 5 inches (slightly less than the diameter of the speaker). The final image information is highlighted below, followed by the before and after post-processing images.



The image was processed using Adobe Photoshop and Adobe Lightroom to increase shadows, vibrance, sharpness, and contrast. The whites were also brought up to help with contrasting the colors.

Overall, though the image seen is not what the experiment was supposed to yield, the stagnant look of the complex mixture reveals some amazing physics. If the experiment were to be redone, more variation in fluid density would increase the complexity even further. This experiment shows what fluctuations in density of a fluid can create during a stabilizing process.