Matthew Schulte
Flow Visualization: Get Wet Assignment
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The purpose of this introductory assignment is clearly given in the name "Get Wet". With many of the students having limited experience in photography, it was a good way for each individual to sharpen their photography skills and experiment with visualization techniques for different flow regimes. This particular image illustrates non-diffusive mixing and folding of two similar fluids of different colors. The fluids shown in this picture are red and black acrylic paint. The reason for choosing these specific fluids was due to their high viscosities, and the colors were chosen because of the way red and black complement each other.

The apparatus used to achieve this image was inexpensive and easy to find. The lighting source was an 8.5 inch clamp light with a 150 watt soft white bulb. The paints were mixed on a 6 inch plastic paint lid and stirred with q-tips and toothpicks. For modeling this flow mathematically, it will be assumed that the flow is similar to that of flow around a cylinder, with the q-tips and toothpicks representing the cylinder. With this assumption, the Reynolds number for the flow can be given by the equation:

$$Re = \frac{\rho V D}{\mu}$$

Where ρ is the density of the fluid, V is the velocity of the flow past the cylinder, D is the diameter of the cylinder, and μ is the viscosity of the fluid. The diameter of a q-tip is roughly 7 millimeters and the diameter of a toothpick is about 1 millimeter. The viscosity of the paint is estimated to be 50,000 cPM [1] which is equal to 50 kg/m*s. The density of the paint is approximately 1050 kg/m^3. The q-tips and toothpicks used to stir and mix the paints were traveling about 5 cm/s. Inserting these numbers into the above equation gives a Reynolds number of about 0.01, indicating that the flow is completely laminar. If the flow was turbulent there would likely have been more mixing of the paint as it traveled past the q-tips/toothpicks and the clear boundaries between the colors would have been distorted, thus laminar flow

makes sense. This phenomenon is also known as “laminar chaotic mixing” and is being studied for a variety of applications, including microfluidics. [2]

The image was taken in a garage during the night to help eliminate unwanted ambient light that could reflect off the glossy surface of the paints. The clamp light was positioned so that it was rotated 90 degrees counter-clockwise with respect to the camera. The flash on the camera was also used as a light source. This resulted in some unwanted glare, but only in a small part of the image that would eventually be cropped out. Figure 1 shows the schematic of the setup.

The camera used to capture the image was a Canon PowerShot SX120 IS. This is a 10.0 megapixel digital camera, and would be classified as a point and shoot camera. The field of view in the original image would be approximately 8 inches, and about 4 inches in the final image after being cropped. The original image dimensions were 2736 pixels wide by 3648 pixels high. The final image dimensions were 1545 pixels in width and 2012 pixels in height. The distance from the lens to the surface of the paint is roughly 6 inches. The camera was set to automatic mode, which resulted in a shutter speed of 1/15 second, an aperture of f/2.8 and an ISO of 80 for the given exposure. The focal length was 6mm. The image was imported into Photoshop using the Adobe CS4 software package. From there it was cropped, and the contrast and saturation were both increased to give the image the desired texture and feel. A few spots with some glare were also airbrushed out. The following pictures show the before and after effects of boosting contrast and saturation.


Before


After

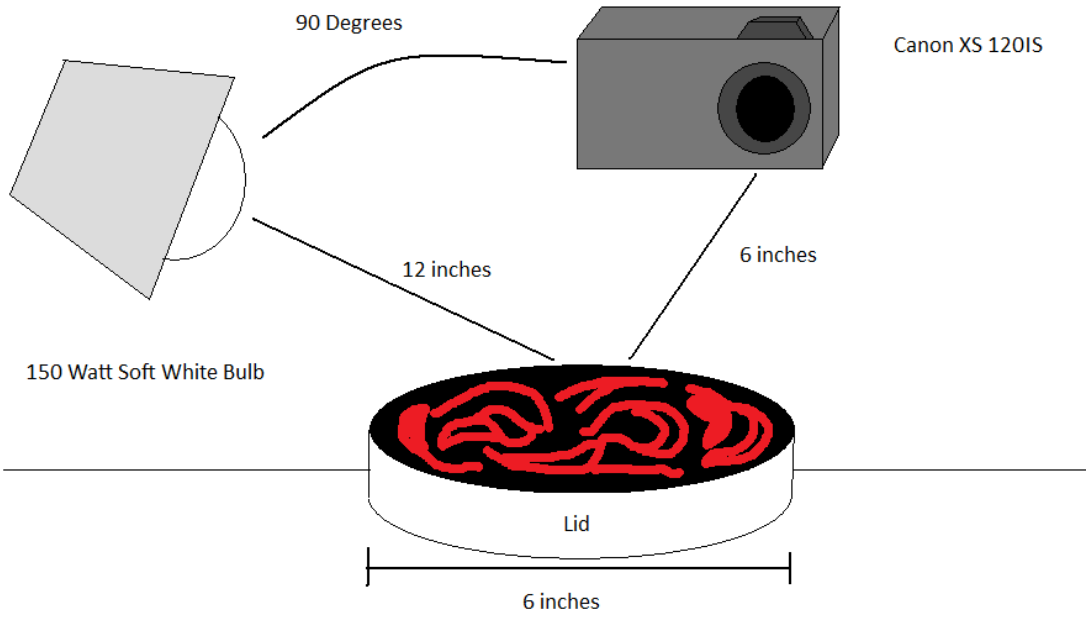

Figure 1

As the artist responsible for this image, there are a few things that I would like to say. I chose to submit this particular image out of all the others I took because of the emotion it brought out in me. I believe it to be a beautiful image, but it also seems to have a darker underlying theme. Some have said the image has a "satanic" feeling, while others said it reminded them of roses. This was the intent of the image, to evoke an emotional response out of people without biasing which particular emotion they felt. I believe that great art is that which will be interpreted differently by each individual who comes into contact with it. On the more technical side of things, I think the image also does a good job of revealing the physics of non diffusive mixing between two similar fluids. The image could be improved with a higher resolution camera like an SLR, as well as a larger canvas to mix the paints on. Also, different lighting could further reduce glare and allow for more area to be captured.

References

[1] http://www.fluidresearch.com/viscosity_chart2.php

[2] Johnston, Hamish. "Sticky walls slow mixing" http://physicsworld.com/cws/article/news/31199 September 19, 2007