Get Wet
Project 1

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Flow Visualization

The purpose of this experiment is to obtain a good image of the fluid phenomena of dispersion. The initial intent was to observe how highlighter ink would disperse in water simplely by placing a highlighter cartridge in a tank of water. However, some modifications to this method were needed, due to the cartridge's inability to release the highlighter ink at a fast enough rate to create visible understanding of the dispersion phenomena. Therefore, the highlighter cartridge was poked 5 times to allow the ink to flow better from the cartridge.

The flow apparatus was set up with several key components in mind. Since a black light was used special percussions were needed to eliminate distracting elements created by the light. A black cloth was placed behind the 2 liter bottle to take away from fluorescent lighting components behind the object as shown in figure 1. Also, all other fluorescent lighting components needed to be removed from the room in order to prevent creating a reflection on the surface of the 2 liter bottle.

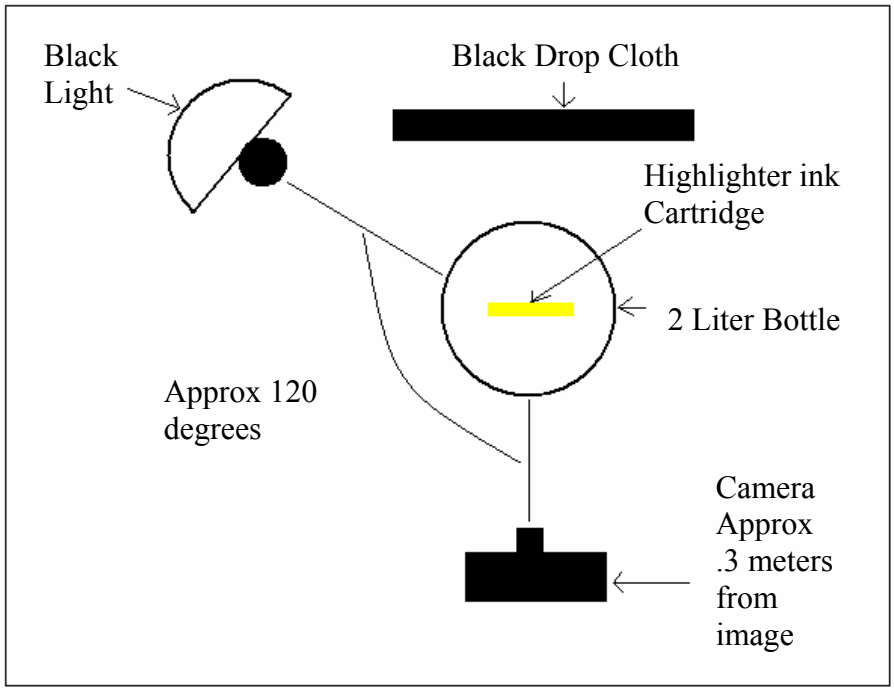

Figure 1: Flow Apparatus (top view, above bottle)

From lectures in class, the apparatus was setup with the lighting and camera offset by an angle of 120 degrees in the same plane as the object. The 2 liter was filled approximately 2/3 of the way full with water to try and use only the cylindrical middle section of the bottle as the field of view. The temperature of the room was held at 24 degrees Celsius. The highlighter cartridge was then placed into the bottle and floated at the surface of the water. The highlighter ink flowed out the holes along the cartridge, and down towards the bottom of the bottle. The highlighter ink is floating down through the water because it has a higher density than the water. The fluids speed was estimated at 5.08 millimeters per second. Noting that the density and the viscosity of the highlighter ink are only slightly higher that that of the density and viscosity of water, the Reynolds number can be estimated to be a value $50 < Re < 500$. In this case the flow is in the laminar regime. The spatial resolution based on the flow speed and field of view can also be found. The calculation for temporal resolution was used knowing the objects speed (5.08 mm/sec and shutter speeds (1/1000 sec) as well as the pixel field of view (.3 meters/2000→.15 mm). From some basic equations we find that the object will move .00508 mm. Due to the slow speed of the fluid ink the object will not smear over any pixels, and will be in focus.

The visual technique used in this experiment was highlighter ink as it moves through water. The entire process was viewed under the lighting of a black light. This illuminated the highlighter ink to show its dispersion and buoyancy characteristics. The flash on the camera was not to be used, because the picture required light given off by the fluid.

The photographic technique for this case relied on the use of a Sony DSC-P92 Cyber-shot 5 Mega Pixels digital camera and some slight Photoshop processing. The

image was taken with the camera approximately .3 meters away from the 2 liter bottle with a focal length of 10.3 mm. The ISO was manually set at 400 while the shutter speed was a time of 1/1000 sec. The aperture was set at a value of 2.8. To create the final image Photoshop was used. In the original image (figure 2) there was a piece of thread around the highlighter cartridge. The spot healing brush was used to try and get rid of the piece of thread. Next, only the red levels of the picture were adjusted, because the red histogram was only for the low (left) regions. This helped bring out each individual stream of the ink. The last Photoshop step, for the initial final image (figure 3), was to use the magic wand to create a black background eliminating any distractions from that background. For the secondary final image (figure 4) a Glowing Edges filter was used to even farther help distinguish the ink as it flowed towards the bottom of the 2 liter.

The final images reveal the highlighter ink's flow downward through the water, showing how the highlighters ink is less dense than water. However, due to the fact that the highlighter ink is so similar to water, you can see that the ink disperses into the water and creates a less dense cloud mixture of ink and water. In the initial final image you can observe the bright green-yellow string like lines along path of the highlighter ink making each individual fluid path more visible. The cloud of ink-water mixture was a slight distraction in this image and could possible be decreased by choosing a less water soluble fluid. In the secondary final image the glowing edges allows you to see a "road map" of each fluid path. This also allows the fluid paths to be show as red, and slightly hides the ink-water cloud as a light green. A future suggestion would be to use an ink with more red light attributes or a camera whose focus is not red light dependent. Overall the image is dramatic and shows the dispersion phenomena.

Appendix

References:
1. Munson, Young, Okiishi, Fundamentals of Fluid Mechanics, John Wiley & Sons 2002

Images:

Figure 2: Original Image
Original resolution
Pixels: X:1944 Y:2592

Figure 3: Initial Final Image

Figure 4: Secondary Final Image