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Flow Visualization
Get Wet Project

This picture was taken for the Get Wet assignment and intends to show surface tension effects. It was also intended to show the boundaries and streamlines that are created between fluid substances when two or more of them begin to mix together. Another interesting point shown in the photo but that was not an original intent of the photo is seeing how a buoyant fluid will move freely across another liquid surface. These effects are very beautiful and I was trying to capture that in a photo. With the photographing techniques used, the flows actually appear more bright and vibrant than when viewed with the naked eye, which helps not only with the scientific intent of the photo, but with the artistic intent as well.

The flow apparatus used to capture this image was a black shallow cookie sheet placed on the ground. It was filled nearly full with water and then drops of an All liquid detergent and vegetable oil mixture were placed on the left edge of the sheet and illuminated under a black light (for a schematic of the apparatus, see the illustration located at the end of the report). Under normal circumstances, detergent and oil do not mix so in order to make the two to mix for the experiment, two equal volumes of the fluids were placed together in a glass and then using a turkey baster, were sucked up and forced back out until the two mixed into one fluid. Once placed on the water's surface, the droplets of the mixture would begin to spread out, yet other parts of the same droplet would remain intact. Multiple droplets were placed at the left edge at about 1" spacing from each other. Each of the drops floated on the surface of the water because the oil (density of .894 g/ml) had made the All buoyant enough to rise above the water. Normally, All is denser than water (1.12 specific gravity), so it sinks. Because the oil forced the All to remain on the water's free surface, we were able to observe the effects that happen when detergent lowers the surface tension of water. This is seen in the regions of dark surrounding the white globs of All. This is where the All is flowing away from the main glob due to the lowered surface tension, but because there are multiple droplets of All present, these flows eventually meet and interfere, and more All builds up. These regions of buildup are shown in the blue regions. The cookie tray is 10"x 15", but the field of view of the photo is actually only about 7"x 10". This gives us a spatial resolution down to approximately .0029". The time resolution of the photo is approximately .0125" because the flow was very slow (only about 1/10" per second) and the shutter speed used was 1/8 second.

The visualization technique used is a type of boundary marking. Because All laundry detergent glows under a black light, it acts as a major component in the driving force of the flow as well as the flow's boundary marker. Only one black light was used, so it needed to be very close to the flow being visualized in order to get adequate light intensity. In this photo, the black light is just out of the frame about six inches above the surface of the water.

In order to properly expose the image, 1600 ISO speed was used with an F/5.6 lens aperture and 1/8 second shutter speed. The image was taken using a Canon EOS Digital Rebel XT (8.2 MP) with a lens focal length of 55mm. The flow was located approximately 18" from the lens, creating a field of view approximately 7"x 10". During

post-processing the image was manipulated by increasing the contrast and lowering the brightness. This made the blue colors more vibrant and made the color and black contrast much greater.

This image reveals how complicated yet beautiful multiple-fluid flows can be. The fact that there are multiple fluids involved make a scientific analysis of the image slightly more difficult, yet the increased complication allows for beautiful surface tension interactions. The streamlines of detergent across the surface of the water (due to lowered surface tension) are marked by their own luminescence, however these streamlines would not even be present at the surface of the water in this way were it not for their interaction with the vegetable oil acting as a buoyant force. A question that I have coming out of this picture is whether fluid motion like this can be predicted using the Navier-Stokes equations. I would imagine that the mathematics involved would be too difficult to pin down, but I'm not sure. All I could use to predict this flow was my own scientific intuition. However, despite not having a solid scientific description (or prediction) of this flow, I was still able to reach my original intent of imaging the interactions, boundaries and streamlines of multiple fluids in a beautiful way. One thing I would like to improve about this is the fact that I *saw* much more beautiful things than this in the tray, yet was unable to properly image them before they had changed and morphed into a different shape. I would like to continue to try to capture the most beautiful aspects of these types of flows as a way to develop this whole idea further.

Flow Apparatus Schematic: