Hannah Schumaker
Flow Visualization
Project 1: Get Wet
Due: 2/12/13

Get Wet – Flow Visualization through Milk Bubbles

The *Get Wet* assignment for the Flow Visualization course is the first project and is designed to introduce students to the world of photographing fluids. It is an open topic assignment, allowing each student to pursue their own individual interests within the umbrella topic of fluids and flow. For this assignment I wanted to capture bubbles. I chose to set this up through the childhood classic – chocolate milk. Nearly every child is fascinated with bubbles and the most common avenue for watching and creating bubbles was chocolate milk and a straw for me.

In order to photograph the bubbles, I filled a clean, clear, glass cup with approximately 1.5" of chocolate milk. I used a plastic straw to blow bubbles at the base of the liquid layer. The diagram seen in **Figure 1** shows the location of each component. The image on the left shows how I set up the system and how I introduced the bubbles. The image on the right shows the positioning of the camera and the method for photographing the bubbles. During the actual photographing of the image, there was little fluid motion. The residual fluid on each bubble can be seen collecting in certain locations, but the bubbles are rather stationary. The camera was positioned directly above the opening of the class, with the lens inside the glass and the edges of the camera resting on the rim of the glass.

For this flow situation, the movement of the flow is limited, which means many of the non-dimensional scales are not relevant here. It would be more appropriate to say we are observing the collection of fluid. In this case the bubbles are created by introducing air underneath the liquid. This air is less dense than the fluid, and so wants to rise up. The air rises up in pockets, and when it reaches the surface it takes a film of liquid up with it, encapsulating the air pocket. The surface tension of the liquid and the tendency toward cohesion force the liquid film covering the air pockets to remain connected to the mass of liquid. Gravity pulls the liquid in the bubble's surface back down to the main mass of liquid, creating the concentrated areas of liquid visible in the photo. As this liquid is pulled down, the buoyancy of the air pocket becomes stronger than the weight of the liquid film and the surface tension combined, and the air pocket breaks free. At this point, the liquid film from the bubble collects in a ring on the adjacent bubbles. This characteristic is also visible in the final image.

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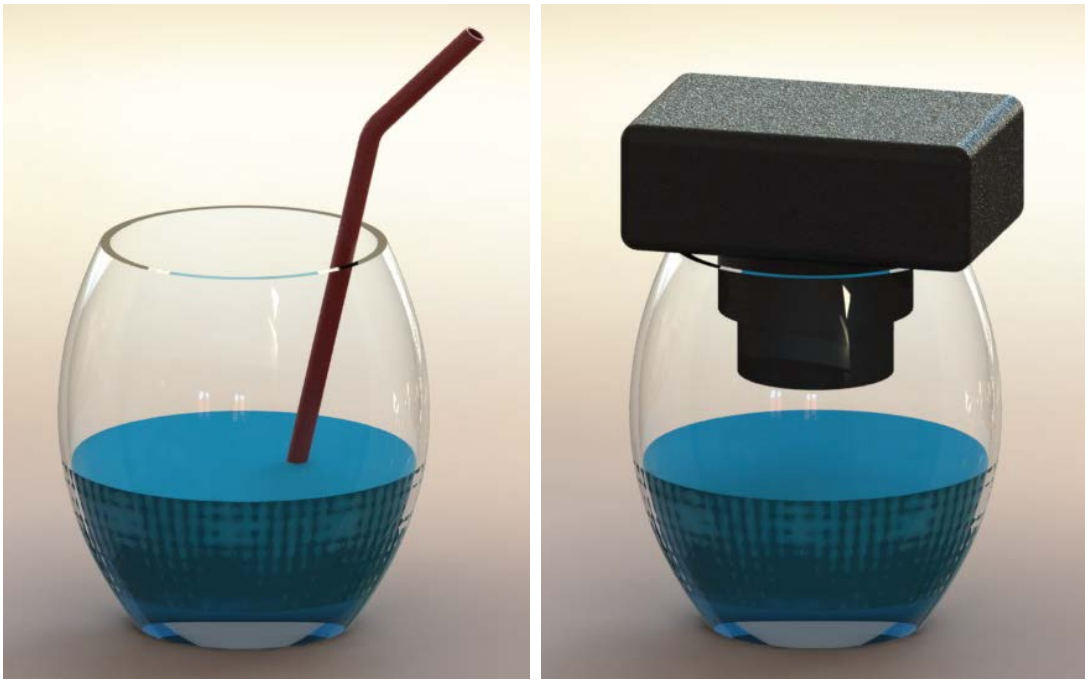

Figure 1. Flow Apparatus

For this image, multiple visualization techniques were attempted. In the end the best result came from a simple lighting of one source. The light was produced by an average indoor light bulb, with the light softened by a frosted glass cover over the bulb. This source was positioned above the glass, as well as horizontally offset. Flash was attempted on several images, but in the end added too much reflection – the end product did not require flash from the camera. The bubbles maintain their surface shape best in milk, and chocolate milk highlighted the concentrations of liquid on the bubble surface better than regular milk.

The size of the field of view was a balance between photographic interest and limitations with detail quality. I chose to include an area of approximately two square inches. This decision was made while taking the photograph. Visual inspection showed that this field of view produced the most interesting variety of bubble type. The FOV was large enough to show several bubbles and the differences in size for each, but small enough to see the details of the fluid. The lens to object distance was rather small – approximately three inches. This value was determined mostly by ease of set up. At this range the camera could rest on the rim of the glass, eliminating the need for external stabilization. A digital camera was responsible for this photo, seen in its original form in **Figure 2**, due to its ability to produce rapid feedback and allow for real-time changes in technique. The camera was a Canon Powershot SX160, and it produced an original and final image pixel size of 2304 x 1728. The image was captured using an aperture of f/3.5, a shutter speed of 1/40, and an ISO of 1600 . The final image was produced by changing only two attributes of the photo in Photoshop. Firstly, the contrast was increased slightly to bring out the variations in fluid concentration. Secondly, the colors were inverted. This change enhanced the small details in fluid concentration and location, as well as creating a more appealing color palette as the original was shades of brown.

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Figure 2. Original Image – Pre Photoshop

The final image can be seen in **Figure 3**. I believe the photo accurately shows the way that the fluid concentrates in the bubble surfaces, which was my intent here. I had hoped to capture more than just the fluid – somehow reproducing the fun that I associate with chocolate milk bubbles, which I think I missed here. At the same time, I think capturing that child-like mood would have required a different focus for this image, detracting from the fluid itself. I especially like the ring of concentrated liquid visible in the center. It shows the after-effects of a bubble popping amidst a sea of bubbles. The difference in gradient on the two sides of this ring illustrates further these after-effects. I find myself wishing for a more focused final product, and one that illustrates the milk concentrations using a different technique. If I were to try this again I think I would use normal milk, and try adding food dye. I think this may eliminate the need for artificial color inversion, which I would prefer.

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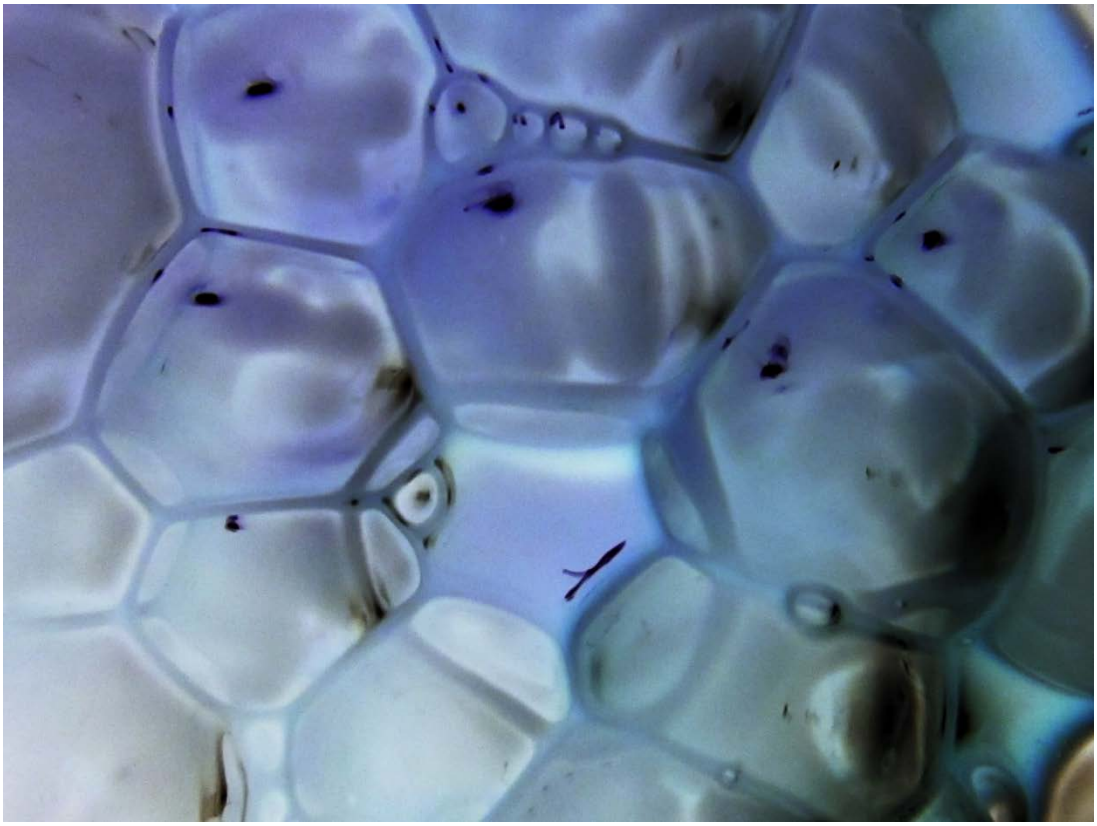

Figure 3. Final Image