Name: Henry Wojcik
Assignment: Get Wet
Course section: CVEN 4153
Date of report: Friday September 18, 2026

For the Get Wet assignment, I recalled doing an experiment when I was younger where milk, food dye, and soap were mixed, causing the dye to be "pushed" away from the soap. The setup used was a plastic container with milk, food dye, and soap. There was a lamp above it for lighting. I also explored using heavy cream, these created stronger and thicker streaks. However, I ran out of it and ended up using whole milk for the final image.

The apparatus is simple; it is a plastic container with roughly 3 cups of milk of milk and food dye in various spots around the container. Regardless of where the dye is, the soap droplet will migrate to the center of the container until it is in equilibrium. The basic flow is dye moving due to surface tension gradient. There were around 3-4 drops of dye, each about half an inch in diameter. The container itself is 10.5 in by 6.5 in and about 2 in deep.

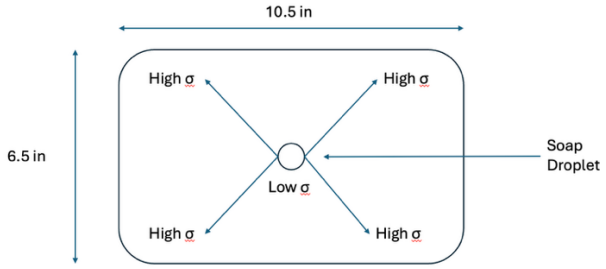

Figure 1. [Shows the basic apparatus setup. The soap droplet is in the center with low surface tension (σ), and areas of high surface tension. This surface tension "pulls" the dye radially outwards from the soap droplet.]

The main effect driving the flow is the Marangoni Effect. Soap is a surfactant, which reduces the surface tension of the liquid in the area near it. This reduction in surface tension causes the higher surface tension areas away from the soap to pull on the fluid in the center, creating the movement [1]The reason we can see this effect so clearly with the milk is because the dye in insoluble in fat[2] .This keeps the dye on the top and separated, helping us to clearly see the streak lines.

The Marangoni number represents the transport rate due to surface tension differences divided by the diffusion of that source (the soap). Since the number is large, the effect of surface tension should dominate, as seen if in the flow. The dye is pulled away from the source, and towards the edge of the container.

$$Ma = \frac{\Delta\sigma \cdot L}{\mu \cdot D},$$

$$\sigma_{milk}[3] = \frac{44 \cdot 10^{-3} N}{m},$$

$$\sigma_{soap}[4] = \frac{25 \cdot 10^{-3} N}{m},$$

$$L = 3.25\ in = 0.083\ m,$$

$$\mu^{\{5\}} = \frac{20 \cdot 10^{-3} N}{m^2},$$

$$D^{[6]} = \frac{10^{-9} m}{s}$$

$$Ma = \frac{\left((44 - 25) \cdot \frac{10^{-3} N}{m}\right) \cdot (0.083\ m)}{\left(\frac{2 \cdot 10^{-3} N \cdot s}{m^2}\right) \cdot \left(\frac{10^{-9} m^2}{s}\right)}$$

$$Ma \approx 10^9$$

Approximately two cups of whole milk were poured into a plastic container with a volume of 9.5 cups. Around a quarter of the bottle of food dye was dropped into 4-5 different spots near the edge of the container. A Q-Tip was then dipped in dawn dish soap, and a droplet of soap was placed into the container. Before the experiment, the milk was allowed to settle for around 2 minutes and was from the fridge. The container was placed on a white table with a warm light above it.

The size of the field of view was approximately 12 cm by 10 cm. The distance from the object was 0.20 m. The lens focal length was 28mm fixed, f/2.8, and a 1.5x crop factor. The camera used was a NIKON Z50 II. The ordinal image size was 5600 x 3728 px, and the final image size was 1300 x 900 px. The image had an aperture of f/2.8, shutter speed of 1/200s, and an ISO of 200. I intentionally used a fixed aperture lens in order to get a close up “fish eye” view of the flow. This allowed it to fill the entire screen, without any distraction of the container.

The image reveals the diffusion of the flow. There are clear streaks and path lines radiating from the center where the soap droplet is. I like there are defined path lines that show flow through a static image. The centering of the drop and how it creates a symmetric image. There is an accumulation of dye at the outer edges of the image, showing the past movement. I still have questions about how much the dye effects the flow. I saw the dye come up from underneath the soap and it appeared to be coming from the soap itself. My intent was to demonstrate flow on a larger timescale. The dye creates a history of where the flow was and unlike other flows, it does not go away. This means even after the soap is done reacting, it is possible to see the path of the dye. I would like to improve the lighting the most. I did this in a poorly lit basement. The warmer colors made the yellow dye blend in and I would have used brighter colors the next time. The next idea would be to make this larger. By taking a container with a larger surface area, it would be possible to create this effect in multiple places, and watch as they collide.

References

[1] “A Scientific Soap Opera, Starring the Marangoni Effect.” UC Santa Barbara, Robert Mehrabian College of Engineering. Accessed September 18, 2026. https://engineering.ucsb.edu/news/scientific-soap-opera-starring-marangoni-effect

[2] “Milk Magic.” Science Museum Group Learning Resources. Accessed September 18, 2026. https://www.sciencemuseumgroup.org.uk/learning/resources/milk-magic

[3] Whitnah, C. H. “The Surface Tension of Milk. A Review.” *Journal of Dairy Science* 42 (1959). Accessed September 18, 2026. https://www.journalofdairyscience.org/article/S0022-0302(59)90760-X/fulltext

[4] Breinig, Marianne. “Surface Tension.” PHYS 221 Core Modules, Module 7. Department of Physics and Astronomy, University of Tennessee, Knoxville. Accessed September 18, 2026. https://labs.phys.utk.edu/mbreinig/phys221core/modules/m7/surface_tension.html

[5] The Engineering ToolBox (2012). *Food Products – Viscosities*. Accessed September 18, 2026. https://www.engineeringtoolbox.com/absolute-viscosity-foods-d_1827.html

[6] Motaghian, M., R. Shirsavar, M. Erfanifam, M. Sabouhi, E. van der Linden, H. A. Stone, D. Bonn, and M. Habibi. “Rapid Spreading of a Droplet on a Thin Soap Film.” *Langmuir* 35, no. 46 (2019): 14855–14860. https://doi.org/10.1021/acs.langmuir.9b02274

Claude AI was used to create an outline and search for sources on the web.. All work in this document both written and images were created by Henry Wojcik.