Image Assignment 1: Get Wet
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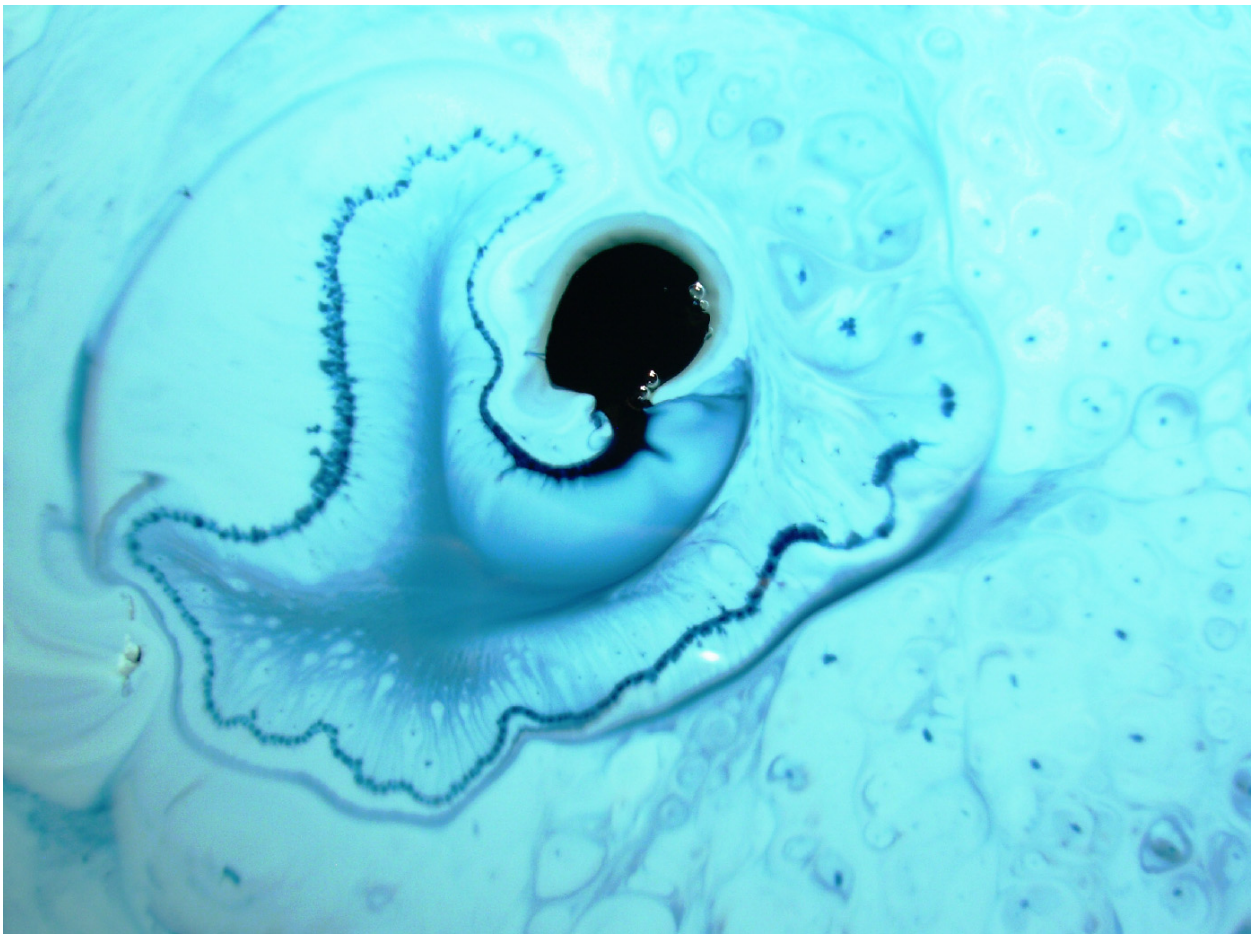
MCEN 4228: Flow Visualization
2/2/09



Introduction

The purpose of this assignment was to "Get Wet" by taking a good picture of a fluid that demonstrates some flow phenomena. My intent for this image was to show the effect that a surfactant, such as soap, has on the surface tension of a fluid such as half and half. Initially a couple drops of food coloring were added to center of plate containing half and half, and a toothpick containing dish soap was place in the center of the dye. This caused the dye to expand outward toward the edges of the plate toward the greater surface tension. This was difficult to photograph because of how quickly the dye propagated to the edges of the plate. The final image was created by pouring a blob of dish soap onto the center of a dinner plate filled with half and half, and then adding food coloring at the interface. This caused the dye to finger out at the interface towards the greater surface tension at the edge of plate away from the soap.

Apparatus

The flow apparatus used to contain the fluid was black, 12 inch diameter ceramic dish plate with a fill diameter of 8.5 inches placed on the floor. A 15 Watt CFL (Compact Fluorescent Lamp) light bulb was the only source of light placed approximately 24 inches from the camera and about 12 inches from the floor. Approximately an 1/8 inch of half and half covered the fill area with a 0.5 inch diameter blob of clear dish soap poured roughly centered in the plate, creating a surface tension gradient. Blue dye was placed at the interface between the soap and milk. This interface caused the dye to finger out and rotate slightly towards the edge of the plate away from the center towards the area of greater surface tension. The approximate Reynolds Number was 284 making the flow laminar [1]. This was calculated by using the fluid properties of half and half (refer to table 1) and approximating the fluid velocity of a finger projection. The amount of time required to produce this image was approximately 5 minutes. The flow velocity was approximated using a stop watch and ruler to follow the distance traveled per unit time of a finger of the main projection of dye. The flow velocity was approximately 4.6 cm/sec.

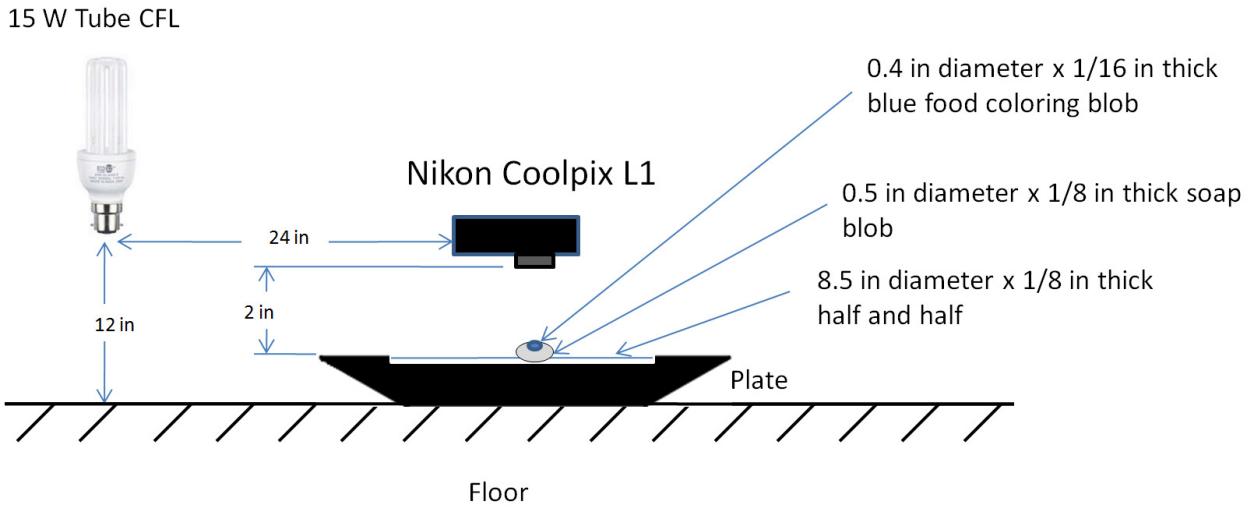


Figure 1: Schematic of Apparatus

Table 1: Fluid & Flow Properties

Properties	Half and Half
Density @ 20 C	1020 kg/m^3 [2]
Dynamic Viscosity	2.1 cp = 0.021 g/cm s [2]
Velocity (approximate)	1.8 in/sec = 4.6 cm/sec
Width of Dye "Finger" projection	~0.5 in = 1.27 cm
Reynolds Number	~284 (laminar flow, Re<2300)

Visualization Technique

The three fluid materials used to produce the image were half and half, food coloring, and dish soap. Blue food coloring was used to seed the half and half, the fluid medium, because it is less dense than milk. This allowed for good visualization of surface phenomena [3]. Very low light was used to take the image. The only source was a 15 Watt CFL light bulb placed 24 inches from the camera at a height of 12 inches. The flash was turned off with the white balance set to cloudy.

Photoshop CS4 Curve Adjustments

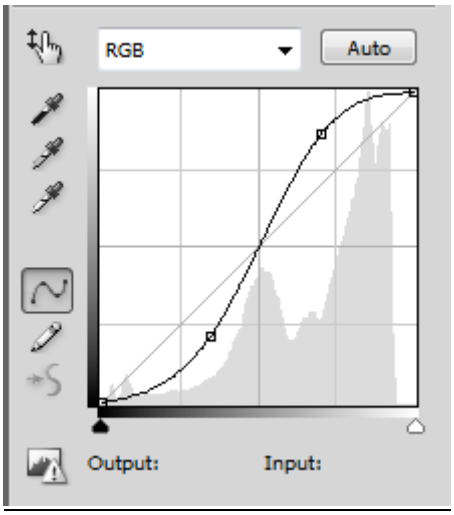


Figure 2: Photoshop CS4 Curve Setting

Photographic Technique

Digital photography was used to capture the image. The camera used was a 6 MP Nikon Coolpix L1 with a Nikkor 5X Optical Zoom lens (6.3-31.4mm, 1:2.9-5.0). The original and final image width and height was 2816 x 2112 pixels and 2405.1 x 1788 pixels respectively. The field of view was about 4 x 3 inches with an object distance of 2 inches. The lens focal length was 6.3 mm. The exposure setting on the camera was set to 0, with the white balance setting on cloudy. No flash was used and the only light source was a 15 Watt CFL light bulb. A macro zoom setting was used to take a close up shot of the dish, with the plate being 2 inches from the camera.

Table 2: Photo Specifications

Field of View (FOV)	4 x 3 inches (width x height)
Object Distance	~2 inches
Focal Length	6.3 mm
Aperture	f/2.9
Shutter Speed	10/60 sec
ISO setting	50
Exposure	NONE, set to 0
Original Image Size	2816 x 2112
Final Image Size	2405.1 x 1788

Conclusions

The image taken reveals the effect that a surfactant has on a fluid. Soap molecules have hydrophilic heads and hydrophobic tails. This means that the head of the molecules has an attraction to water and the tails are repelled from the water. The hydrophobic tails of the soap molecules are attracted to the hydrophobic fat globules in half and half. This forms an aggregate called a micelle [3]. In the image taken, the blue food coloring droplets are a result of micelle formation. The fingers will continue to expand and churn until the soap dissipates into the milk and forms micelles around the fat globules creating equilibrium. I think that this image demonstrates surface tension driven fluid flow very well in a beautiful and artistic visual. The only aspect that I would like to improve is sharpness of the image. This could probably be achieved using an exposure, tripod, and better lighting when taking the picture. Further exploration into surface tension driven fluid flow could include experimenting with different fluid media such as: low fat milk, heavy cream, or fat free milk. Also different seeding fluids other than food coloring could also be used.

References

1. http://www.engineeringtoolbox.com/laminar-transitional-turbulent-flow-d_577.html
2. http://www.nationaldairycouncil.org/NR/rdonlyres/52BEEEB2-9DF5-4555-B5F2-D01C12F27ED2/0/TABLE14.pdf
3. http://www.exo.net/~pauld/activities/fluids/soapconvectionmilk.html