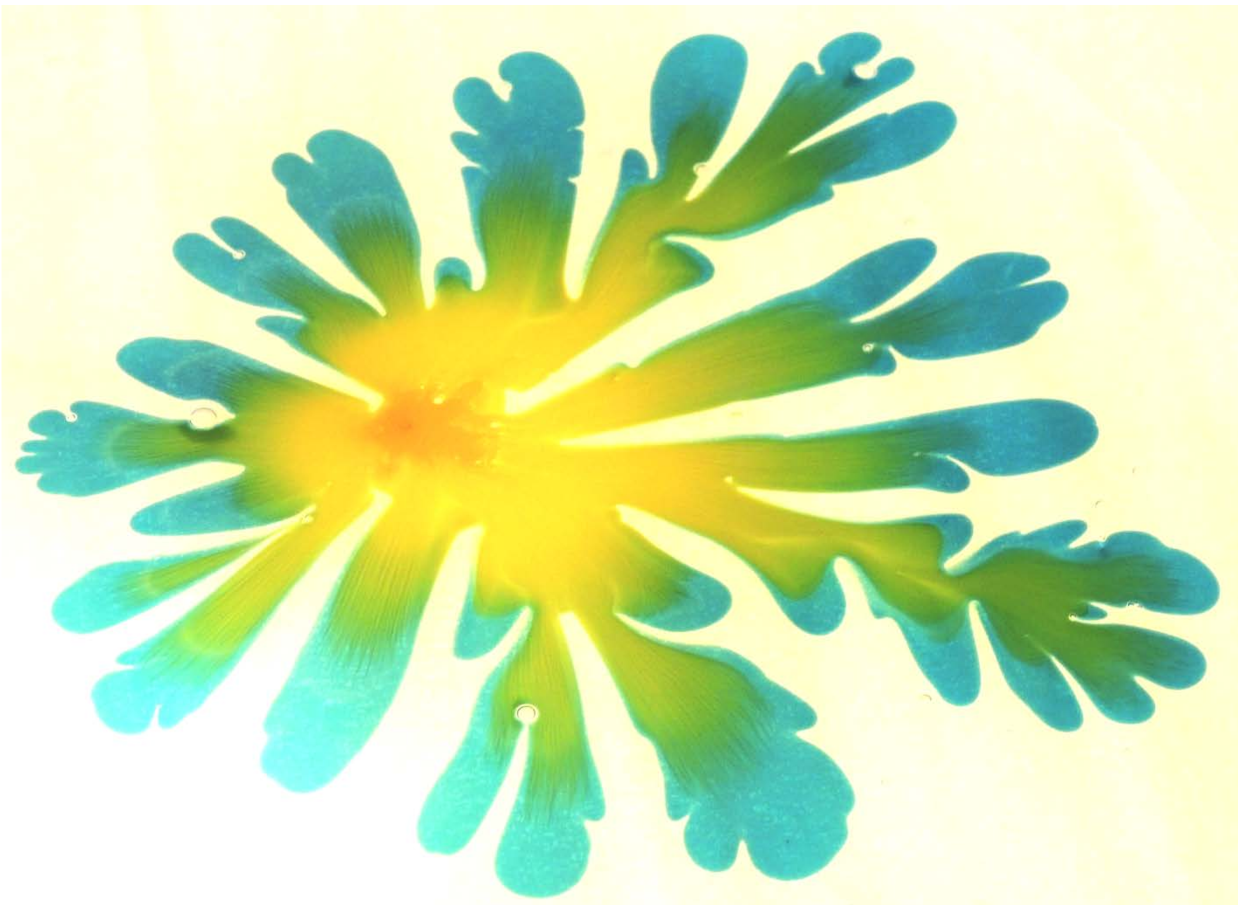
Hele Shaw Cell

Team First Photo



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The purpose of this assignment was to choose a project to experiment and photograph with a team. As a team, it seemed like we were drawn towards doing a project that involved using bright colors. The hele-shaw cell looked both interesting and like it would produce a beautiful image. A hele-shaw flow is a flow that is produces then there are two horizontal flat parallel plates separated by an infinitesimally small gap. These plates are most commonly glass. The glass allows us to see the flows that happen between the plates. One of these plates has a small hole in the center to allow for fluid to be injected while the other plate is completely solid. A diagram of this setup is shown below.

When a fluid is injected through the small hole, an image with webbed fingers is made. In this trial, we initially poured clear detergent on the bottom plate before placing the other plate on top. After we place the top plate down, we injected blue detergent through the small hole. The blue detergent quickly spread out into fingers. After that, milk with yellow food coloring was injected through the hole. The yellow and blue quickly mixed to form a beautiful gradient of colors. The milk stays within the boundaries of the detergent because it is less viscous. This less viscous fluid does not exert enough force on the detergent to break through it. When doing an experiment with a hele-shaw, it is important to use a Newtonian viscous fluid or else the physics will behave differently. When the gap in between the two plates is small, the pressure in between them is a function of x and y (horizontal plane) as a function of time. When the second fluid, which is usually the less dense/less viscous fluid is injected it penetrates into the more dense fluid and this creates the round-ended fingers. [1] The Reynold's number for a fluid in a hele-shaw cell is usually very low. We can calculate this Reynold's number by using the density of milk to be 1035 kg/m^3. The velocity of the milk flowing moved an inch in 2 seconds, or 0.0127 m/s. The average length of a finger was half an inch, or 0.0127 m and the viscosity of the milk is 0.003 Pas. With these numbers we can calculate a Reynold's number

$$Re = \rho v L/\mu$$

$$Re = \frac{(1035\frac{kg}{m^3})(.0127\frac{m}{s})(0.0127m)}{.003Pas}$$

$$Re = 56$$

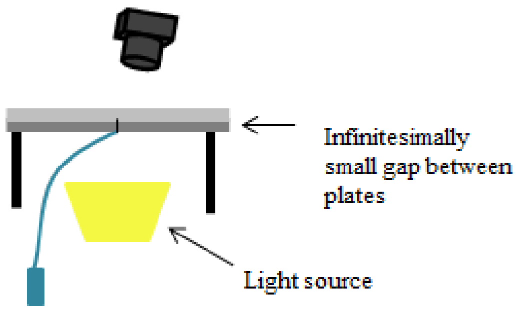
This low Reynold's number shows how laminar the flow in a hele-shaw is. With the velocity, we can also calculate how much the fluid moved during exposure. Taking the velocity of the fluid to be 0.0127 m/s and knowing that the shutter speed was 1/40, we get a distance of 0.3175 mm.

To perform this experiment, my group and I did a variation of trials. We had clear and blue laundry detergent, milk, water, food coloring and olive oil. In our initial trials, it seemed like the color combinations that we were using were not contrasting well with each other and therefore we were unable to capture a nice image. We took this as a sign to make the colors more intense by using more food coloring. As a group, we decided what colors of milk or water should be used with which detergent. We tried to choose colors combinations that would look well together. Everyone took turns cleaning the plates after each trial to avoid any unwanted mixture of fluids. Brandon was responsible for injecting the fluids that we mixed into the hele-shaw while Devin, Elizabeth and I took pictures on our individual cameras. In all of our trials, we poured a base liquid on the bottom plate before putting the top plate on and injecting the next liquid. The liquid was injected using a small syringe with thin plastic tubing that was inserted into the small hole, as seen in the diagram below. For these images, there was a lot of natural light as we were outside. We also used a lamp under the hele-shaw to illuminate the background as well as the colors of the fluids we were using.

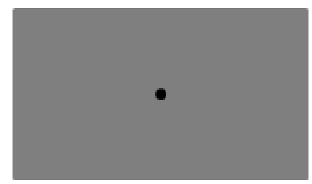
The distance from the object to the lens was about six inches vertically. My image was captured at an straight down angle. The camera that I used for this was a Nikon P510 which is a digital point and shoot. The original images are taken at 4608x3456 pixels and it was cropped to be 4072 × 2856 pixels to get rid of some white space. The focal length of my lens ranges from 4.3-180 mm. The f/-number of the camera lens ranges from f/3-5.9. In my captured image, the aperture was F4.0, the ISO was 400 and the shutter speed was 1/40 of a second. In post-processing, I adjusted the curves by making an S-curve in order to bring out the blues and greens of the fingers. I also adjusted the contrast a little bit to make the image sharper and make the blues more intense.

I believe that the asymmetry of the fingers in my image do a good job in reveling the physics of the hele-shaw cell. I really like the colors in my image. I am personally more drawn towards bright and cool colors and I think there is a good representation of this in my image. I like that the blue and yellow combing to make green, my favorite color. The fingers in this image are really large and they resemble a large splatter of paint. I believe that the blue in my image could be a bit more intense and stand out more. Although the blues at the right of the image do have a nice color, I think it could be better if I used an aperture that allowed from less light to come in and therefore have a darker blue. I believe that the bubbles in this image add a nice touch to this image.

[1] N.p., n.d. Web. <http://rspa.royalsocietypublishing.org/content/245/1242/312.short>.



Side View



Top View of bottom plate