Group Project 1

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Group Beta
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MCEN 4228: Flow Visualization

The enclosed image was created in an effort to examine Saffman-Taylor instability in the Hele-Shaw cell. The final image did not fulfill the original intent, but instead reached towards a different goal, established in the act of making the photo itself. The Saffman-Taylor instability was seen in a small way at the edge of the image, however it was not generated in the traditional manner of using the cell with the dye forced in through the bottom, but instead a puddle of low viscosity fluid that was open to the air was injected with a more viscous dye to create the image.

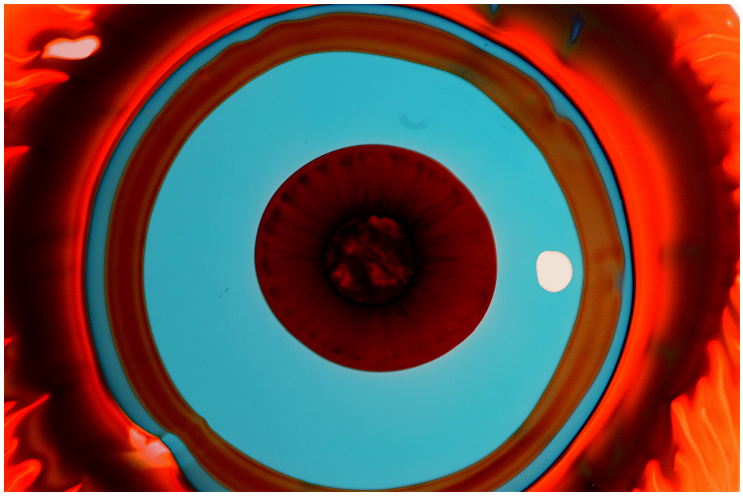

Figure 1: Boundary Layers and Saffman-Taylor Instability

The final set-up did not utilize the Hele-Shaw cell for anything more than a back-lit table. Karo corn syrup was placed in a circular puddle on the flat surface with a diameter of roughly 2 inches. Diluted red dye was then inserted in the center of the puddle in the bottom by using a syringe. The dye solution was created by mixing dye and water at a 1:1 ratio. Alternating colors, concentric rings were then formed by repeating this process five times. Each circle of dye was infected with roughly 1 mL of solution at a rate of 1 mL/s. This process is illustrated in Figure 1.

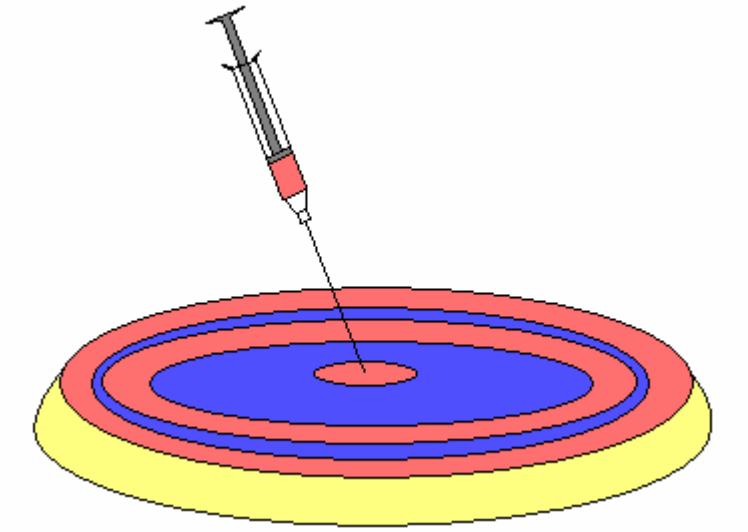

Figure 2: Experimental Set-Up

Boundary layers formed between the colors of dye as the dye mixtures of different colors were injected into the center of the concentric circles. When the first dye injection took place the dye spread evenly in a circle. Then, as the dye tried to rise as it was less dense than the corn syrup, the Saffman-Taylor instability was seen in the fingering at the far edges of the image. This is caused by the more dense corn syrup on top piercing the layer between itself and the dye as it tries to fall. The dye then rises in these areas and causes a fingering pattern to be seen. This effect was only seen in the first injection of the dye.

In the subsequent injections of the dye mixture the Saffman-Taylor instability was not seen as the dye stayed on the top of the corn syrup to entire time. On these injections, the needle of the syringe would pierce the top of the previous level of dye and force a circle to spread from this point. As the dyes would not diffuse into each other, the new circle of dye would force the previous circle to condense as it was forced outward, causing some of the different intensities in color from ring to ring. This is seen most prevalently in the outer most ring of red where a dark band has formed. The dye was injected at a constant rate from each injection to the next. With the Reynolds number being estimated at around 10, this put the flow well in the laminar realm. The photo was taken with all fluids at rest, making the time resolution 1 pixel crossed/particle.

In order to light the image all light was generated under the table. The table top was transparent enough to let adequate light through the top surface and to the camera sensor using a single 60 Watt bulb. The light would travel through the table top, most colors would be absorbed by the dye, and the dye would let the viewed color reflect back to the camera. In this case, the reflected colors are blue and red. No alterations were made between the original image and the submitted image.

Camera specifications and settings are given in Table 1:

Table 1: Camera Settings and Properties	
Camera	Canon EOS Digital Rebel
Lens	Macro
Focal Length	50 mm
Aperture	f/10
Resolution	6.3 MP
Shutter Speed	1/60 s
ISO	400
Lens Distance	2 in

The image itself is roughly 1.5 inches across.

While the image did not succeed in accomplishing its original attempt, the process yielded what I would call a successful image. There are sharp lines and bright colors that make the image interesting to look at. It is almost like looking onto the eye of an unknown creature. The red circle in the middle particularly gives the impression of a red eye looking back at the viewer. To improve the image, different materials could be explored instead of the typical dye and corn syrup. The group was having success earlier in the project working with dyed hydrogen peroxide. The hydrogen peroxide would accelerate the fingering; however it would dilute the dye to the point that the vibrant colors were not realized. Overall I do believe that we did come up with a unique image for our submission, despite using techniques explored many times before.

References

1. Notes on Advanced Environmental Fluid Mechanics, November 18, 2002.
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2. Crowe, Clayton T. (2005). Engineering Fluid Mechanics.
New Jersey: John Wiley and Sons.