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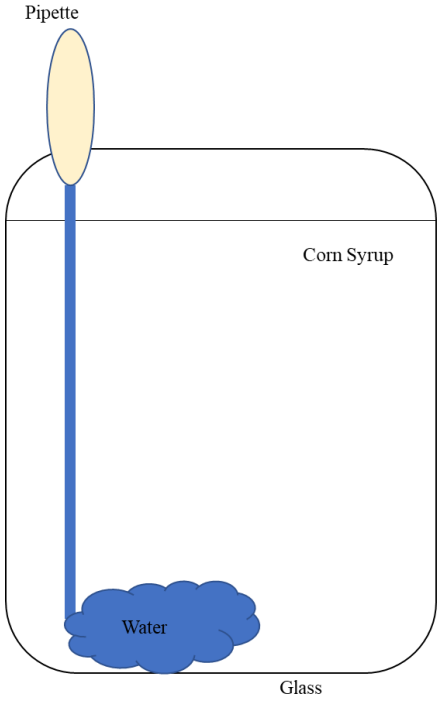
Team Third Report

12/09/19

The photo that will be analyzed in this report was taken for the third team photography project of the flow visualization course. This photo was captured with the intent of showing the motion of fluids exhibiting differences in density. There are very interesting mechanics that occur when one fluid rises or sinks through another due to differences in the properties of the two fluids. In this case, the only property that was investigated was one in density. The photo was taken by my teammates as I conducted the experiment.

The flow apparatus seen below was very simple in this case. It involved a small glass filled with corn syrup, into which a pipette would inject a stream of water colored with food dye. The glass that was filled with corn syrup was rather small, as it was a cylindrical glass with an inner diameter of approximately 1.5 inches. The pipette also had a very small opening, on the order of 1-2mm and would contain a volume of about 1mL of water. This amount of water would be pipetted towards the bottom

of the glass so that the motion of it rising through the denser corn syrup could be captured.



In this case, it is necessary to investigate the Grashof number of the fluid in addition to other dimensionless numbers. The reason that the Grashof number is so important in the mechanics seen is due to their driving force being the buoyancy of water in corn syrup. This buoyancy is driven by concentration gradients on a small scale and by density differences on a larger scale. The equation for the Grashof number can be seen below:

$$\mathrm{Gr}_c = \frac{g\beta^*(C_{a,s} - C_{a,a})L^3}{\nu^2}$$

Where

$$\beta^* = -\frac{1}{\rho}\left(\frac{\partial \rho}{\partial C_a}\right)_{T,p}$$

This Grashof number will relate the buoyant forces to the viscous forces acting on the fluid. In this case, it is very difficult to give an exact value for the Grashof number, but it can be approximated to Re/Pr. In this case, the Prandtl number of water at atmospheric pressure and 20 degrees Celsius is 7.0. The Reynolds number can be found as follows, approximating the velocity from the shutter speed and information gathered during the experiment.

$$Re = \frac{\rho v D}{\mu}$$

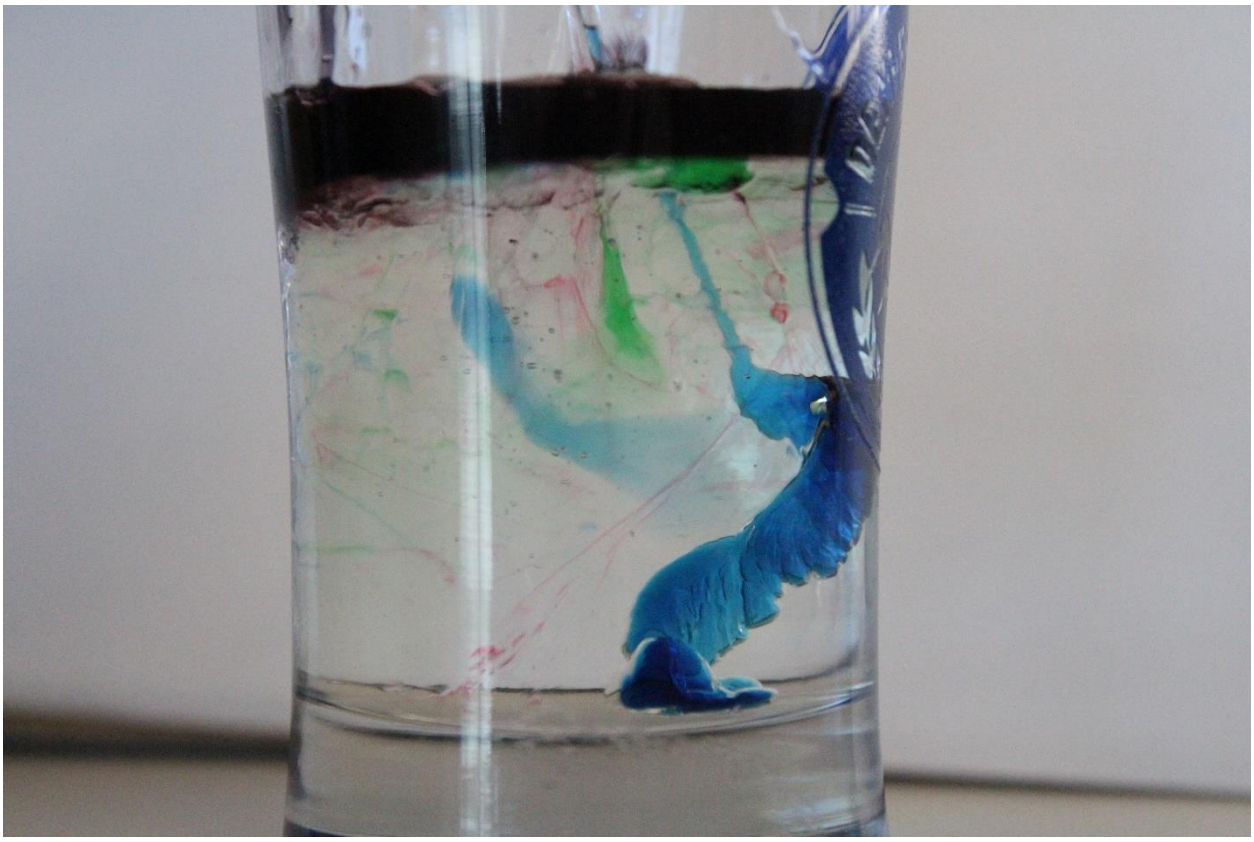
$$7543 = \frac{0.99 g/cm\text{^}3 * 2 cm/s * 3.81\ cm}{0.001}$$

In this case, Re/Pr = 1078, indicating that buoyancy is very significant in the motion of this fluid and plays a much bigger role than that of the viscosity of the fluid.

The visualization technique here used food dye in the water to be able to visualize the path of the fluid up through the corn syrup. The lighting was provided by several overhead bulbs as well as natural light through a window. A white background was used to isolate the fluids being visualized from other distractions that might have been in the field of view of the camera itself.

The field of view in this photo was small, only about 3 inches wide and 4 inches tall, which was sufficient to capture all of the flow occurring in the glass. The distance from the lens to the subject was approximately 6 inches. The lens focal length was 49 mm with an F-stop of f/5.6. This photo was taken using a Canon EOS Rebel T6 digital camera, resulting in an image that had a size of 5184x3456 pixels. On this camera, the ISO was set to 6400, with an exposure time of 1/640 seconds, in order to be able to capture the flow of the water up through the corn syrup, which happened rather quickly. This photo was then processed in photoshop to crop it, remove some imperfections in the background, and increase contrast and colors so as to better see how the fluids are acting.

This image revels the interesting interaction of a less dense fluid injected deep into a more dense fluid. The fluid physics are shown well due to the ability to capture photos at a high shutter speed so that details could be revealed. Due to this, the intent was fulfilled, however, if this was to be repeated, I might choose more vibrant colors and lighting to make the details more pronounced and focus more on the artistic intent.



Unedited Photo