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IV 3
MCEN 5151
11/23/2020

Gravity Driven Flow Through Liquids of Different Densities

The intent behind this image is to show density effects in a liquid flow. It can be seen the light oil sits on top of the water while the heavier dye sinks to the bottom. Furthermore, the dye slows down as it reaches the denser saltwater mixture at the bottom of the glass and experiences vortex shedding.

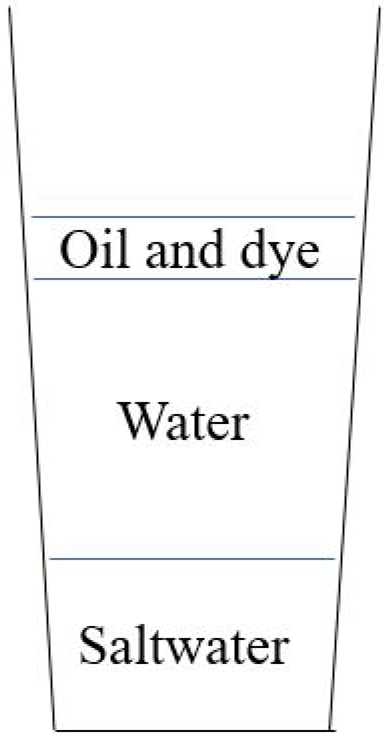

Figure 1: Photographic setup

The setup of this image is shown in the figure above. First, salt was mixed into water filling about a quarter of the glass and let sit. Regular water was then carefully added to avoid mixing with the saltwater until the glass was about two thirds full. Separately, three drops each of four different colored dyes were gently mixed into a bowl with olive oil. The oil and dye mixture was then carefully poured into the glass to observe the flow. This is a gravity driven flow, since the heavier dye sinks to the bottom of the glass due to gravity. The Reynolds number for this flow can be estimated as shown below:

$$Re = \frac{UL}{\nu} = \frac{0.005\ m/s \cdot 0.05\ m}{1.3 \cdot 10^{-6}\ m^2/s} = 192\,,$$

where U is the estimated velocity of the dye flow, L is the characteristic length, in this case the diameter of the glass, and ν is the kinematic viscosity of water. This is a low Reynolds number that corresponds to a laminar flow[1]. Vortex shedding can also be seen as the dye falls through the water, which is caused by the inertia of the dye and viscosity of the surrounding water[2].

Kroger brand assorted neon food coloring with pink, blue, green, and purple colors were used for the visualization in this experiment. A kitchen light above the glass was used for the lighting in this video. In addition, a white shirt was used in the background to better visualize the darker dyes.

The field of view in this video is about one foot wide and the glass was also about a foot away from the lens. This was filmed with a LG G8 smartphone and the dimensions of the video are 1920 x 1080 pixels. The focal length is 27 mm, the f stop is f/1.5, and the frame rate is 30 fps. For post-processing, the video was sped up by 4 times since the process of the dye falling was fairly slow. In addition, audio was added to supplement the video.

This video reveals the interesting effect of dye falling through liquids of different densities. The physics caused by the different densities can be seen by the heavier dye falling through the lighter oil and water, then slowing down as it reaches the saltwater. Some improvements can be made to this video. Better lighting and less dye could have been used to better visualize the flow.

References

1. Berman, Abraham S. "Laminar Flow in Channels with Porous Walls." *Journal of Applied Physics*, vol. 24, no. 9, 1953, pp. 1232–1235., doi:10.1063/1.1721476.
2. Agrawal, Meenu, et al. "Nonspherical Liquid Droplet Falling in Air." *Physical Review E*, vol. 95, no. 3, 2017, doi:10.1103/physreve.95.033111.