University of Colorado
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MCEN 4151: Flow Visualization

2021 Fall Image/Video Second Report

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1. Introduction

As I was coming up with ideas for my second assignment I utilized the internet for options. Within minutes of a simple "cool flow visualization experiments" google search I was watching a YouTube video. From slow motion videos of the popping of water balloons to timelapses of the oceans tide in Hawaii there was a wide range of experiments that I could do. One experiment in particular had an effect on me, it was called "Water and Wine"[1]. This experiment shows two different fluids trading places.

The purpose of this video was to understand the forces of fluids better while exploring the concept of flow visualization and how to best represent a phenomenon through a lens. This report will thoroughly go though how to reconstruct this experiment, classify, and explain the flow phenomenon.

2. Experimental Set-up and Materials

To be able to capture pictures and videos of the water to wine phenomenon a physical experiment had to be conducted. Using our personal computes for image editing I was able to create the experiment using the following materials:

Materials Used In Experiment		
Material	Description	Quantity
Canon EOS Rebel T5 DSLR	18.0 Megapixel Digital single-lens reflex camera	1
Tripod	Portable support, elevate and stabilization device	1
White back drop	Flat white surface that can be used as a background	1
Lighting	Lighting such that the experiment is well visible	2
Small identical glasses	Clear shot glasses to see the fluid transfer	2
Wine	The upper fluid were capturing	2-8 cups
Water	The lower fluid were capturing	2-8 cups
Thin water proof card	Acts as a gate to allow fluid to transfer	1

Table 1:This table shows the quantity of each component required to run the experiment.

To set this experiment up you must first set find a level and sturdy surface to conduct the experiment. Fill one glass container completely full of water, attempt to fill it as full as possible. Next fill the other glass container completely full with wine. Place the card over the water glass. While holding the card onto the glass, flip the water glass over and set it including the card on top of the second glass. Make sure to line the glasses up so that they are even, attempt to exactly match the lids. Next, move the card so that there is a small gap at the edges of the glasses. Over the next ten minutes, the liquids will exchange fluids and eventually exchange places. The lower dense fluid will rise to the top while the more dense fluid will sink and fill the bottom container. Shown in Fig.1 is a schematic of the experimental set up during the experiment.

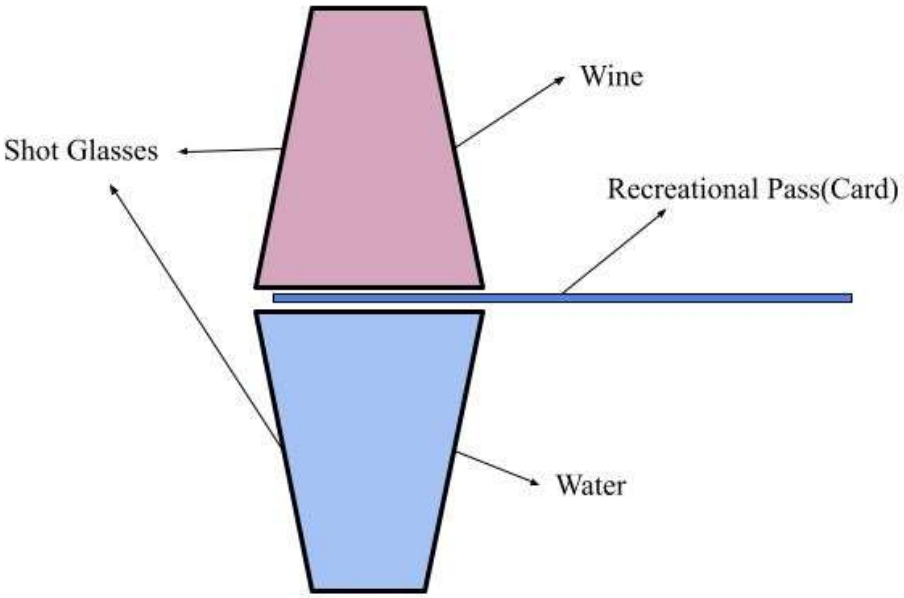

Figure 1: Experimental Setup

3. Flow Phenomenon

At first it is almost as if it is magic. But obviously it is not done by magic, it actually ends up being because of simple science. Water has a density of 977 kg/m^2 [2]and wine has a density of 1060 kg/m^2. Wine is typically 8-9% more dense that water[3]. They are differently dense and we can use that to our advantage. Basically, the lighter(less dense) fluid will float to the top while the heavier liquid will sink to the bottom. A figure of this idea is shown in Fig.2. The same result would be seen if there were no card entirely but this allows for a more visual effect. This experiment can be performed using many different liquids. For example water and wine, water and oil, wine and oil, or water and whisky. All that is needed is two liquids that have different densities. In order to get a more clearly defined separation liquids such as water and oil work well because they are hydrophobic[4][5]. In some ways this phenomenon can be represented mathematically with buoyancy forces. The density of fluids affects their buoyancy. The buoyant force is equal to the weight of the fluid displaced. The greater the density of the fluid, the less fluid that is needed to be displaced to have the weight of the object be supported and to float. For example: since the density of salt water is higher than that of freshwater, less salt water will be displaced, and the boat(object) will float higher. This can be connected to this experiment if you think of the second fluid as an object. This can be represented in Eq.1

$$F_1 = AP_{\text{atm}} = \rho_{\text{F}} g A h_1$$

$$F_2 = AP_{\text{atm}} = \rho_{\text{F}} g A h_2$$

Equation 1: $F_{\text{B}} = F_2 - F_1 = \rho_{\text{F}} g A(h_2 - h_1) = \rho_{\text{F}} g A h = \rho_{\text{F}} g \text{V}$

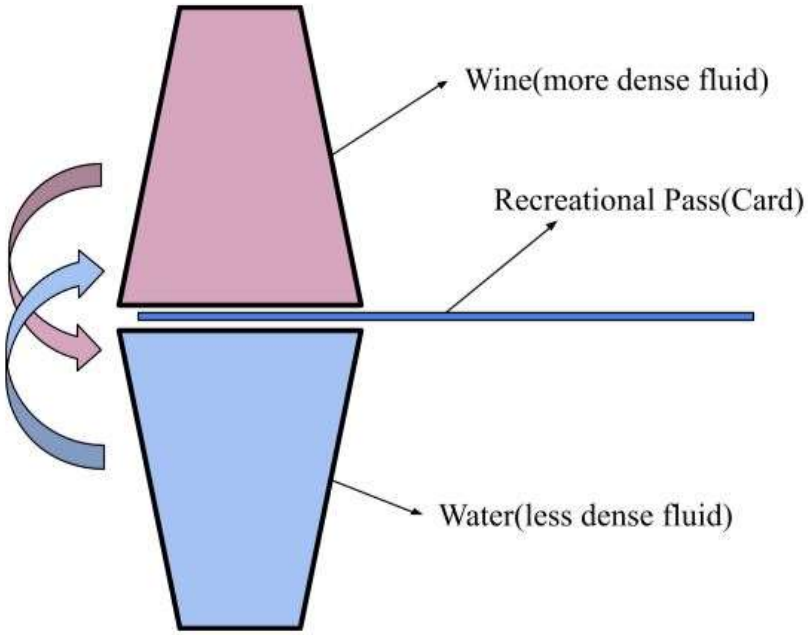

Figure 2:Transfer of fluids with different densities

4. Photographic Technique

To begin you must first set up the "scene", I did this by placing one shot glass on the other on the table and my camera across from it. Using the cameras view finder eyepiece and constantly adjusting the tripod until the camera could stand still with the card in the middle of the frame. Then I placed a poster board behind the scene and checked to make sure no parts of the wall could be seen in the cameras frame. I then placed two lamps on either side the camera and covered them with white towels. The apparatus is shown in Fig.3.

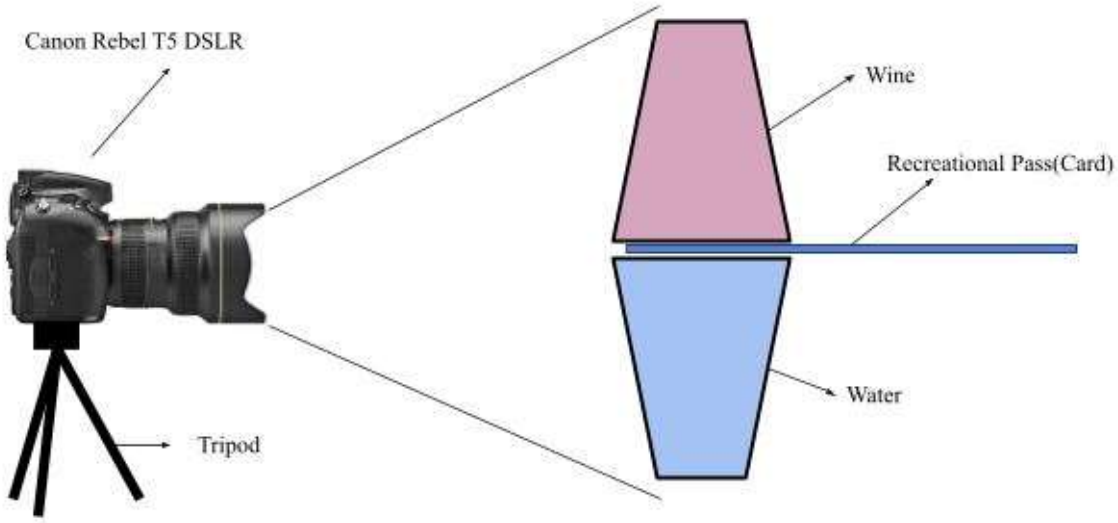

Figure 3: Photographic Setup

I used an additional object to help focus the camera on the center of the two shot glasses. I also used food coloring to make the wine a darker color. I would suggest getting a darker color wine if possible to increase the contrast between the wine and the water. I wanted the raw look to the footage to show the viewer it wasn't magic and was just mysterious. Represented in Fig.4 is three images taken at different time steps to show the transfer of fluid.

Figure 4: Pictures of phenomenon, 30 seconds(left image), 55 seconds(middle image), 83 seconds(right image)

5. Conclusion

After performing the experiment, recording the experiment, re-performing, re-recording; it was amazing how often I saw this similar phenomenon all around me in every day life. If I was to go about doing this experiment again, there are a few things I would have changed. First being, the focus in the video was a bit off and if I took more time to on focusing I think I could have produced a more crisp video. Secondly, the lighting did not turn out the way I wanted it to, if I would have gone to a light room on campus and conducted the same experiment, I believe it would have turned out better. Other than that I was really cool to learn more about fluid forces as well as flow photography and visualization effects. I really enjoyed making this video.

6. References

[1] maricv84. "5 Awesome Experiments Using Liquid - Cool Tricks You Can Do at Home." *YouTube*, YouTube, 10 Aug. 2015, https://www.youtube.com/watch?v=gpLq2NKjoiY.

[2] Cohen, Jennifer M. "Water Density and Temperature." *Water Density versus Temperature - The Key to the Galileo Thermometer*, http://www.4physics.com/phy_demo/Galileo_thermometer/galileo-thermometer-d.html.

[3] "Hydrometer Confusion: Wine Making: Creative Connoisseur." *Hydrometer Confusion | Wine Making | Creative Connoisseur*, http://www.creativeconnoisseur.com/newsletter/files/497deafe6be1b2efc87df8ac6071e459-162.html.

[4] Cohen, Jennifer M. "Water Density and Temperature." *Water Density versus Temperature - The Key to the Galileo Thermometer*, http://www.4physics.com/phy_demo/Galileo_thermometer/galileo-thermometer-d.html.

[5] "Hydrophobic." *Merriam-Webster*, Merriam-Webster, https://www.merriam-webster.com/dictionary/hydrophobic.