# Half and Half Poured into a Glass of Canola Oil

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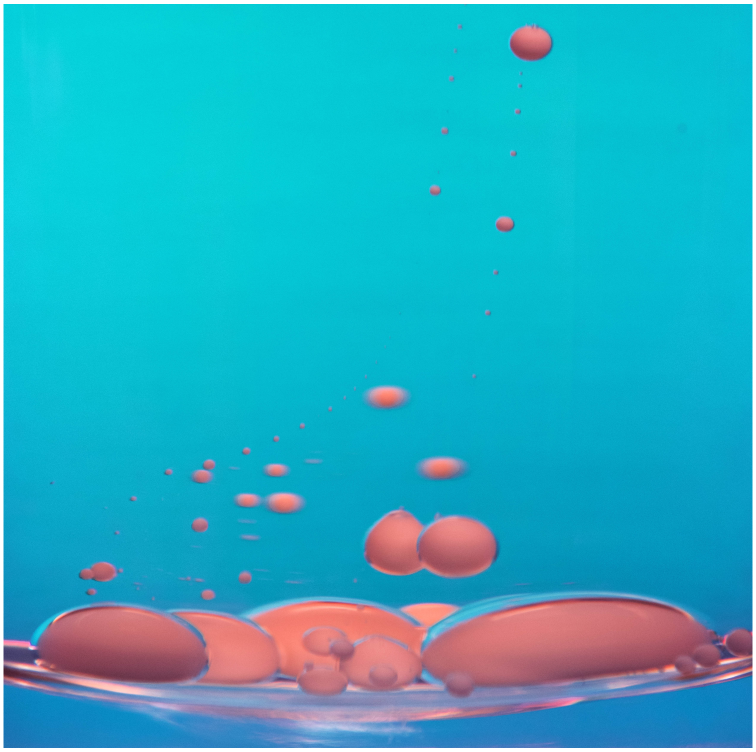

**Fig. 1 Final Image**

## Introduction

The purpose of the Get Wet assignment is to "get your feet wet" in flow visualization and fluid flow. For this assignment I wanted to put a different spin on the traditional oil in water experiment and decided to use half and half mixed with oil. When mixed with water, half and half spreads through the water in turbulent plumes resembling smoke. Quite the opposite happened when the half and half was dropped in the oil, and it made for a very interesting photo. Post-processing was the most lengthy part of this project, as the original image had some ugly colors that made for a less-than-pleasing photo. Figure 1 shows the final photo used for submission for the assignment. This report will go over exactly how the image was made and explain the physics behind the fluid flow.

## Experiment

### Experimental Setup

The setup of this experiment was quite simple. A diagram of the experiment is shown in figure 2. The experiment was carried out on my kitchen counter at home.

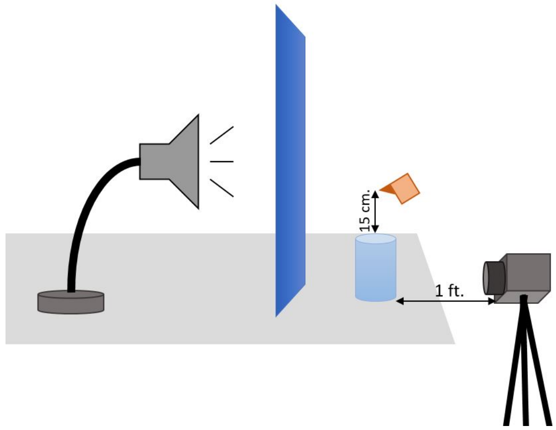


**Fig. 2 Experimental Setup**

1 cup of canola oil was poured into a clear pint glass. The glass was set on the table and adjusted so it was in front of the backlight. A transparent blue plastic sheet was held in front of the lamp and behind the pint glass to diffuse the light and add more color to the image. The camera was set up on a tripod and set 1 foot away from the glass. Half and half (about a tablespoon) was then poured from 15 cm above the top of the pint glass. As the half and half was poured, the camera's shutter release was pushed and multiple photos were taken of the half and half falling into the oil.

**Flow Physics**

Assuming no resistive forces such as drag and assuming constant gravitational acceleration, the speed of the half and half as it hits the oil can be calculated using the following equation of motion:

$$v^2 = v_0^2 + 2a\Delta y \tag{1}$$

We can assume that the half and half started at rest before being poured into the oil. $\Delta y$ is the height the half and half fell from (see figure 2), and $a$ is the gravitational acceleration on Earth. Solving for $v$, it was found that the speed of the half and half upon impact was about $1.72\frac{m}{s}$. This result doesn't take into account resistive forces from air resistance but for the purposes of this experiment serves as an accurate estimate of the speed of the half and half.

Once the half and half hit the bottom of the glass it began to float back up through the oil for a few seconds. This is when the photograph shown in figure 1 was taken. The following three photos show this phenomenon in action:

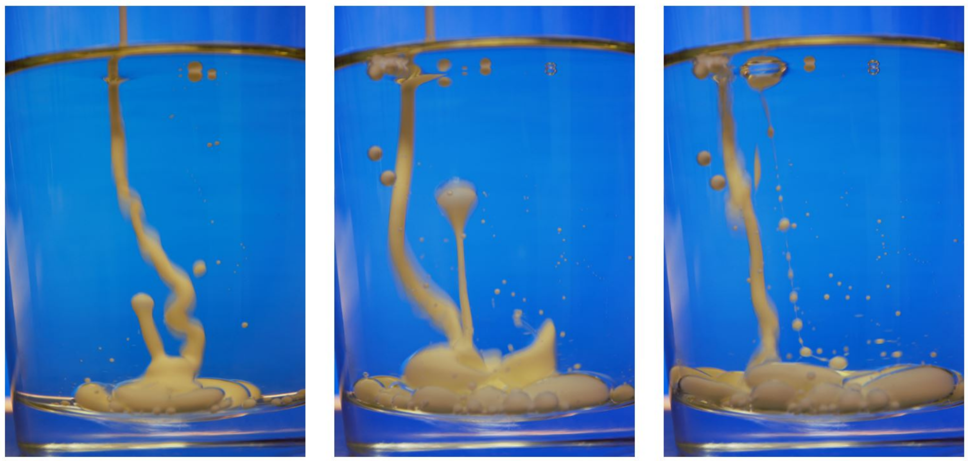

**Fig. 3 Half and Half Floating Up Through Oil**

The first photo shows the half and half first hitting the bottom of the glass. The half and half then seems to bounce off the bottom and float back up through the oil, breaking into small beads in the process. This phenomenon could be explained by the buoyant effect. The average density of half and half is about $1020\frac{kg}{m^3}$, while the density of oil is about $920\frac{kg}{m^3}$. The two fluids have about a 10% difference in density. The half and half has a higher density and will therefore sink in the oil according to Archimedes Principle, which states that an object with the same density as the fluid it's immersed in will float. This occurs when the upward buoyancy force acting on the object equals the weight of the object, which acts downward. In the case of this experiment, the buoyant force of the oil acting on the half and half is less than the weight of the half and half, so at first, the half and half sinks to the bottom. The calculation of the buoyant force is given by the following equation:

$$F = \rho_{fluid} g V_{body} \tag{2}$$

Where $\rho_{fluid}$ is the average density of the oil through which the half and half falls, $g$ is the acceleration of gravity on Earth, and $V_{body}$ is the volume of the half and half being dropped into the oil (1 tablespoon). The resulting force is $.134N$. This result can be compared to the weight of the half and half, which can be found by the following equation:

$$W = mg \tag{3}$$

Where $m$ is the mass of the half and half and $g$ is the acceleration of gravity. The weight of the half and half found using the above equation was found to be $.196N$. Because the weight of the half and half is more than the buoyant force of the oil acting on the half and half, the half and half will sink in the glass. However, half and half and oil are immiscible fluids, so the half and half begins to split into beads and the weight is reduced. Some of these beads are able to stay suspended in the oil for a time before slowly sinking back to the bottom of the oil.

## Image Capture

This image was taken using a Nikon D3300 DSLR camera with an 18-55 mm, 1:2.5-5.6 lens. The exposure time was 1/50 seconds with an f-stop of f/6.3 and ISO 800. As stated in the experimental setup, the pint glass was 1 foot away from the lens of the camera. The field of view of the original image is about 8 centimeters from the bottom of the glass to the top of the oil, and about 4.5 centimeters from one side of the bottom of the glass to the other. The original photo has a size of 4000x6000 pixels and was cropped to a size of 3471x3445 pixels. As one can see from figure 3, the colors before image manipulation were not very appealing, so extensive color manipulation was performed to make for a more pleasing photo. Photoshop was used to manipulate the color in the image. First, both the hue and saturation were reduced. Next, the color balance was adjusted to bring out magenta and blue in the image. The edits made in Photoshop are shown in figure 4 below:

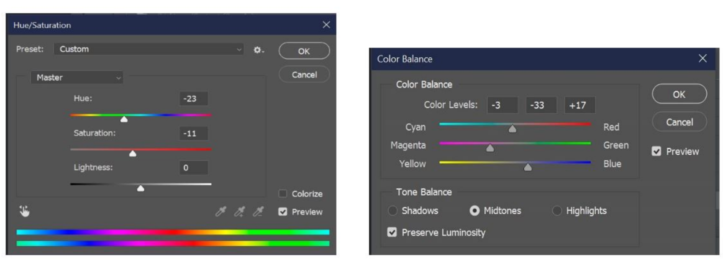


**Fig. 4 Photoshop Manipulations**

In order to capture the image I set the camera shutter to burst mode, so when the half and half began falling into the oil, the camera took continuous photos until I stopped pushing the shutter release. This ensured that I got multiple photos of the phenomena and could pick and choose which photo I liked best.

## Conclusion

I feel this image reveals the unique and bizarre ways fluids interact with each other. The final image has an almost animated look to it, and the colors add a calmness as well as another element of strangeness to the image. I am really happy with how the image turned out. It took me a long time to decide on what colors and cropping to use but I feel the edits I made were effective in improving the photo without impeding on the flow physics involved. The only thing I would improve on in this image is fixing the small amount of motion blur. It was really hard to find a balance between shutter speed and aperture. To develop this visualization further, I might consider using a taller container with more oil to give more time for the half and half to fall to the bottom of the container, therefore giving me more time to capture the image.

## References

1) "20-1 Physical Mechanism of Natural Convection." Fundamentals of Thermal-Fluid Sciences, by Yunus A Cengal et al., 5th ed., pp. 822–825.