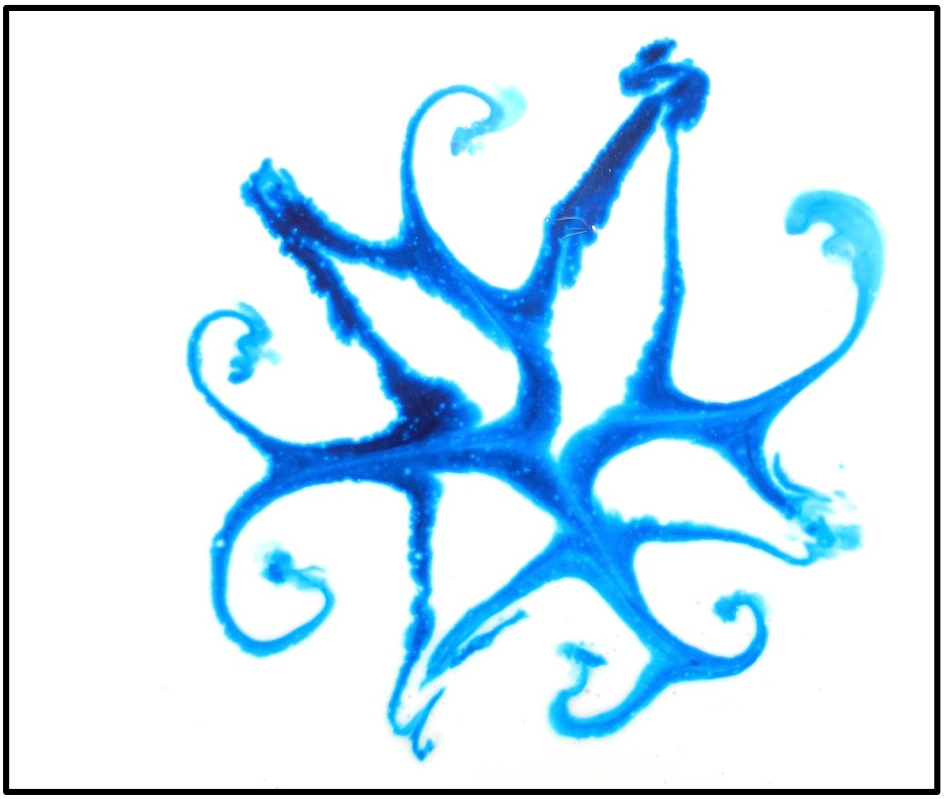
Group Project 3: Painting In A New Medium



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Purpose

In the third and final group project, this experiment endeavored to explore the qualities of a non-Newtonian fluid. The purpose of this experiment is to demonstrate how a densely packed non-Newtonian fluid interacts with a less dense fluid. The intent behind this experiment was to create art in a new medium not only the photographic aspect of the experiment, but also in the experiment itself.

Visualization Technique

This experiment required a simple list of materials in order to be executed:

- 2 cups of corn starch (household)
- 1 cup of water (household)
- Neon food dye (King Soopers)
- 1 bowl (household
- 1 knife (household)
- Standard ceiling light (household)
- 1 camera

With the use of the aforementioned items, the experiment can be conducted. In order to create a non-Newtonian fluid with the use of cornstarch, 2 cups of cornstarch must be mixed slowly with 1 cup of water in a bowl – this creates Oobleck, as named by Dr. Suess. As the mixture thickens, the mixing spoon can be discarded and the experimenter can mix the fluid with his or her hands. The mixture is completely mixed when the Oobleck feels like a solid in one's hand but dissolves like a liquid from the hand. Varying thicknesses are allowable depending on this experiment. One way to confirm that the Oobleck is acting like a non-Newtonian fluid is to let it sit in the bowl and the quickly poke the surface of the fluid with a finger and pull back – the surface will vibrate (similar to jell-o) but it will not break, leaving the tip of the finger clean of Oobleck. Once this property is confirmed, the experiment can be continued. To create art on the surface of Oobleck, one drop of food dye from a neon blue bottle is dropped onto the surface of the Oobleck. This dynamics of this process will be explained in the subsequent section. A small kitchen knife can then be used to lightly penetrate the spot wherein the drop sits on the Oobleck, and the knife's edge can be dragged through the surface to create images. Whenever one continuous line has been drawn and is complete, the knife must be pulled out of the fluid vertically, or perpendicular to the surface, to minimize disturbance. In order to light this experiment, the standard kitchen light was used while placing the bowl on the kitchen table. The flash setting on the camera was used because the walls of the bowl were deep and created shadows. A schematic of the experimental set-up is shown on the left.

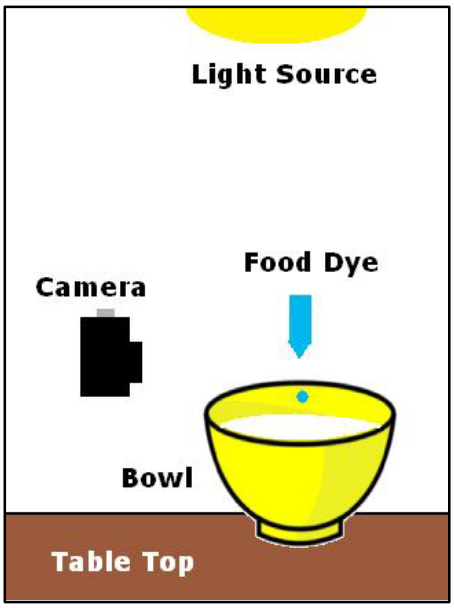

Figure 1. Schematic

Approach

The impact of the food dye on the Oobleck creates a fluid interaction due to the velocity of the dye and the difference in densities of the dye and Oobleck. The image shows that the dye can be manipulated over the course of minutes and stays stagnant as images are taken – there is little to no movement of the dye in the Oobleck because of the large difference in densities. However, because Oobleck is a non-Newtonian fluid, its density cannot be easily measured.

Characteristically, non-Newtonian fluids shift densities depending on the conditions or forces to which they are subject. Because the Oobleck initially acts like a solid when the dye impacts the surface but then slowly allows some of the dye to dissipate through capillary action in the fluid, this investigation will attempt to quantify the force of the drop of dye on the surface of the Oobleck. First, some assumptions will be established to justify the values used to characterize food dye.

1. The room in which the experiment takes place is 68°F or 20˚C.
2. Air resistance of the dye falling in air can be neglected.
3. The shape of the dye as it free falls can be approximated to a sphere.
4. Food dye is primarily made of propylene glycol, so this will be the fluid property observed.

With these assumptions, the standard properties and dimensions of the fluids and experimental set-up must also be identified.

Density of propylene glycol: $\rho = 1040\ kg/m^3$ [3]
Distance between dropper and bowl (traveled by falling food dye): 3in or 0.0762m
Initial velocity of the food dye in air: $V_o = 0\ m/s$
Diameter of the dye drop before impact: L = 3/16 in or 0.0047625m
Gravity: $9.8\ m/s^2$

The primary equation used to indicate the force of the drop on the Oobleck surface is Newtown's 2nd Law:

$$F = ma$$

Where *F* is the force in Newtons, *m* is the mass in kg, and *a* is the acceleration of the drop in m/s^2. Knowing the density and volume of the drop of dye, the mass can be solved:

$$\rho = \frac{m}{V}$$

Where ρ is the density and *V* is the volume. By plugging in known values, the mass of the drop is as follows:

$$m = \left(1040\frac{kg}{m^3}\right) * \left(\frac{4}{3}\pi\left(\frac{0.0762m}{2}\right)^3\right) = 0.2409kg$$

Now that all values are known, the force can be solves as well:

$$F = (0.2409kg)\left(9.8\frac{m}{s^2}\right) = 2.36\ N$$

Though it is difficult to quantify the density of the Oobleck from this value, it is interesting to know that such a small force is capable of conditioning the Oobleck to even briefly act as a solid and then as an extremely dense liquid wherein the drop of dye does not dissipate through the fluid over time.

Photographic Technique

The digital camera used in this experiment is a Nikon S9050. The following settings were used to capture the image:

- Focal length: 4.5mm
- Digital zoom ratio: 1.00 (macro setting – on)
- Aperture: f/3.5
- Shutter speed: 1/30s
- Scene Mode: Backlighting (flash – on)
- ISO: 200

The original image began at the dimensions of 4000 x 3000 pixels and was cropped to a size of 2611 x 2195 pixels. Because the white of the Oobleck and the vividness of the food dye were ample, the flash lighting on the camera created a slightly washed out but contrasted image. No post-processing was done other than slightly increasing the sharpness of the image to bring out more defined borders between the dye and Oobleck. The following histograms show the how color spread changed before and after editing.

Figure 2. Original Histogram

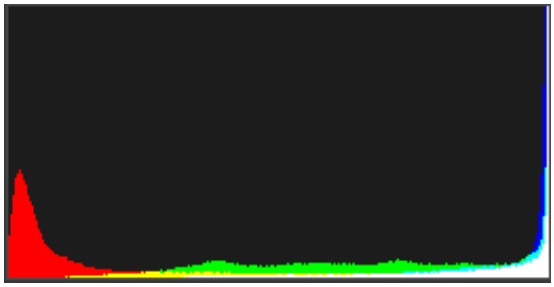

Figure 3. Final Histogram

The image of the flower on the Oobleck demonstrates how the highly dense Oobleck interacts with a less dense fluid. This method is also a unique way in which to create art through flow visualization before the photography phase of the experiment. The images below demonstrate this comparison between the original and edited images.

Figure 4. Original Image

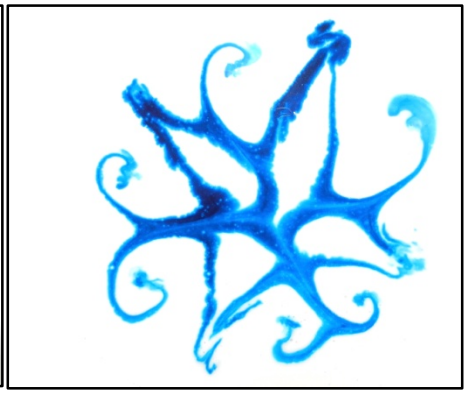

Figure 5. Final Image

Conclusion

One of the greater criticisms of this image was that the flash on the camera created a slightly washed out image. Realistically, the image could also have been much clearer. In a future endeavor, the use of a tripod might be conducive to a clear image, considering the fast shutter speed.

Apart from issues with the photography during this experiment, painting through a new medium was oddly soothing and fascinating all at once. Oobleck defies the scientist's intuition, and "playing" with Oobleck for multiple days during the production of this experiment was easy to do. It was later found out that the concept of drawing on the surface of a fluid is also a type of Japanese art – personally, this experiment is reminiscent of what talented baristas do every day in the foam of a cup of coffee. Being able to create art on dual levels – within the experiment and within the photography – was an interesting challenge and endeavor that resulted in the privilege to exercise one's creative mind. I loved this experiment because the phenomenon was fascinating and I felt that I had suddenly acquired a new hobby.

In the future, it would be interesting to use multiple colors and small paint brushes to see how intricate the paintings can become on the surface of the fluid. It would also be important to measure how long it takes for the food dye to dissipate within the Oobleck over time, since the water in the Oobleck mixture would be evaporating and the mixture would return to being corn starch.

Works Referenced

[1] http://mindtrekkers.mtu.edu/docs/Lessons%202012/Oobleck%20(Small%20Scale).pdf

[2] http://en.wikipedia.org/wiki/Non-newtonian_fluid#Oobleck

[3] http://aliciac.hubpages.com/hub/An-Oobleck-Recipe-and-Fun-Experiments-With-a-Non-Newtonian-Fluid