Group Project 2

Resonant Liquidity

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Flow Visualization

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The purpose of our group project was to capture images of a non-Newtonian fluid subjected to various frequencies of reverberation. The phenomenon was produced by placing a corn starch and water mixture in a subwoofer cone facing upwards and signaling the subwoofer with different frequencies and volumes until the most fascinating images were captured. The camera was placed in different positions for the different photographs.

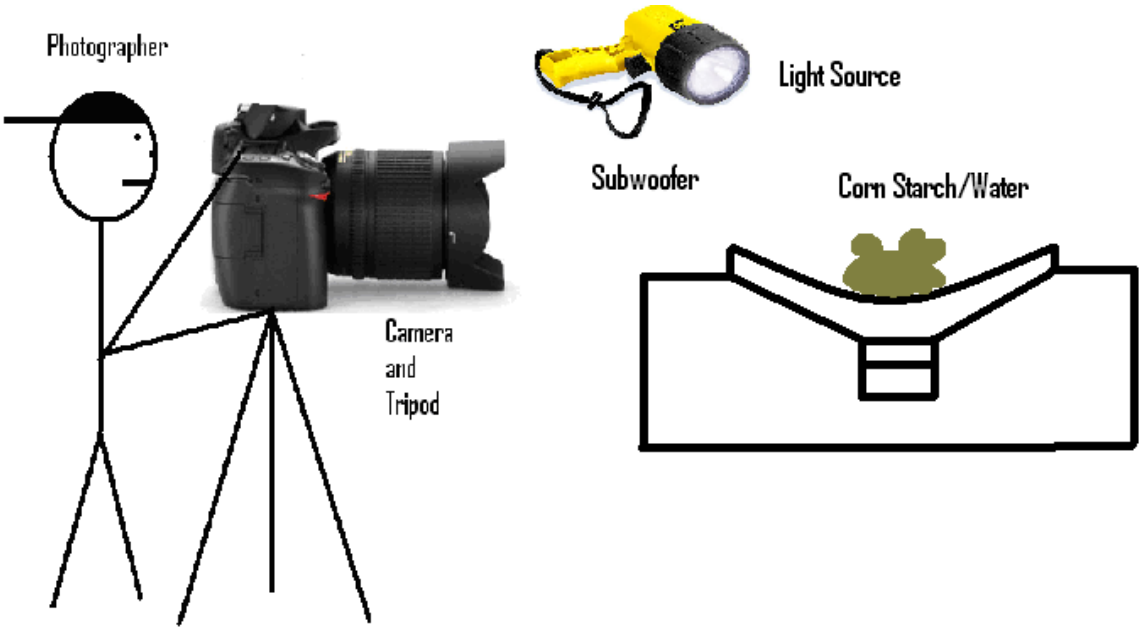

Figure 1 - Experimental Setup

The corn starch and water mixture is non-Newtonian fluid which means it thickens or has an increase in viscosity with shear. So as the liquid moves past itself it imitates a more solid substance rather than a liquid like water. By using the subwoofer to vibrate and excite the fluid, it is in turn increasing the viscosity and causing it to behave in interesting ways. When the correct frequency and amplitude of signal is found, in our case a 75 Hz sine wave, the fluid can be caused to float in the air and change shape. The setup can be found in Figure 1 above. The corn starch and water composition was simply poured into the subwoofer cone and the subwoofer signaled with a program designed to reproduce consistent frequencies.

The ratio of corn starch to water was 3:2 to provide the best results. Corn starch can be purchased at any grocery store and water was used from the tap. The experiment was performed at room temperature. The lighting was provided by a halogen light held above and behind the camera pointing towards the subject.

Matt Blessinger's Image:

Table 1 - Matt Blessinger's Image Settings

Photographic Technique	Value
Field of view	8 in. x 8 in./ 64 in^2
Distance from object to lens	15 in.
Lens focal length	112 mm
Type of camera	Nikon D80 w/ AF-S Nikkor 18-135mm, 1:3.5-5.6G ED lens
Original picture size	3872 x 2592
Final picture size	2976 x 2592
Aperture	F/5.6
Shutter speed	1/60 sec.
ISO setting	100

Table 1 gives all of the image and camera settings used to capture the non-Newtonian fluid flow of the oobleck (cornstarch and water mixture). I set the lens focal length to have a field of view that could capture the just enough of the subwoofer cone, thus cutting out the unnecessary details. I set the Nikon's shutter speed to a 1/60 sec. because it allowed me to capture the individual waves in the fluid without motion blur. The other settings were automatically set by the camera. After the initial image was captured, several Photoshop techniques were performed to further highlight the fluid flow. In Photoshop I increased the contrast curve to brighten the mixture so it was whiter. I also cropped the photo to emphasize the actually fluid flow and remove the unnecessary parts of the setup.

To create this picture, the program was set to a 75 Hz sine wave at a medium volume. This caused the oobleck to form these ripples that oscillated back and forth. Once there was a set pattern to the fluid, I poked the middle of it with a pencil and it created a hole. The hole then moved around pond until it settled in its final location (the one in the photo). What I really liked about this photo is the fact that the shear stresses, causing an increased viscosity, allowed the fluid to hold its form, especially with the hole. The hole I caused would not collapse during the photo session. I believe that the fluid's viscosity was so great on the inside wall of the hole that it's weight nor the vibrations could break the surface tension. The photo captured the fluid phenomenon that I was going for. For further studies, I would like to film the fluid. During the film, the frequency and amplitude would be changed to show how it affects the fluid's motion. The major thing I would change about the experiment is the lighting. It was hard comprising between one and two light bulbs because it either washed out the fluid or didn't provide enough light.

Kevin McCoy’s Image:

Table 2 – Kevin McCoy's Image Settings

Size of the field of view	10” x 8”
Distance from object to lens	8 Inches
Lens focal length	80mm
Lens specifications	18.0-135.0 mm f/3.5-3.6
Type of camera	Nikon D80 Digital SLR
Original Image Size	3872 X 2592
Final Image size	3872 X 2592
Aperture	F/5.6
Shutter Speed	1/100 second
ISO Setting	100

The image has been altered slightly in Photoshop. The contrast was altered to brighten the subject of the image. The curves tool was used to highlight the subject of the image. The brush tool was used to eliminate some unnecessary portions of the image and bring the focus back to the phenomenon. The photo was not cropped to include the speaker surround in the image. I believe this extra feature adds depth and background to the image.

The image reveals the physics behind a non-Newtonian fluid like corn starch and water. As shear is created within the fluid when the subwoofer is excited, the fluid’s viscosity increases and causes it to behave in an interesting fashion. Then through experiment, the correct frequency and amplitude is found and the fluid will appear to hover in the air from the force of the subwoofer and it’s resultant increase in velocity. I am still curious about exactly what makes a fluid non-Newtonian. Also, I am not quite sure why at certain frequencies the substance will hover, I am assuming it is similar to the resonant frequency of a solid object, especially since the fluid is imitating a solid object the more viscous it becomes. I belive the intent was fulfilled. I would like to take a video next time. Just after the photographs were taken the fluid had broken through the speaker and further experimentation and recordings were not possible. I think a larger pool of the substance plus a larger speaker with an enclosure could yield some interesting results. I would also like to use a more transparent fluid with dye inside so the internal flow could be visualized.

Jason Ortmann's Image:

Table 3 – Jason Ortmann's Image Settings

Size of the field of view	8" x 8"
Distance from object to lens	12 Inches
Lens focal length	75mm
Lens specifications	18.0-135.0 mm f/3.5-3.6
Type of camera	Nikon D80 Digital SLR
Original Image Size	3872 X 2592
Final Image size	3872 X 2592
Aperture	F/5.5
Shutter Speed	1/60 second
ISO Setting	100

Some changes were made to the image in Photoshop in order to enhance the image. The brightness was first increased to increase the exposure of the image. Then, the brightness of the darker sections were increased using curves in order to show more of the image to the viewer without making the already bright sections too intense. Finally, the "full light" feature was increased once again to increase the overall brightness of the image so that as much detail as possible was visible.

The final image well represents the effect of the extreme forces on the non-newtonian fluid. Though the still image looks as though it is little different from any other ordinary fluid, the still picture shows how the fluid acts under such circumstances. I like that the rapid motion of the bulk of the fluid could be captured as a still frame while keeping the rest of the fluid still as well. However, I feel that observing the behavior of the fluid first hand is something that is incredibly hard to capture in one single image. For that reason, I would consider taking a video if I were to pursue the concept further. I believe that capturing the motion in video would further help the viewer understand the behavior of the fluid under the given forces. Though the motion of the fluid over time could be portrayed in a better way, the intent of the image was still fulfilled and I am very satisfied with the final image.

References:

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