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MCEN 4151: Flow Visualization
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Team First – 2016 Report

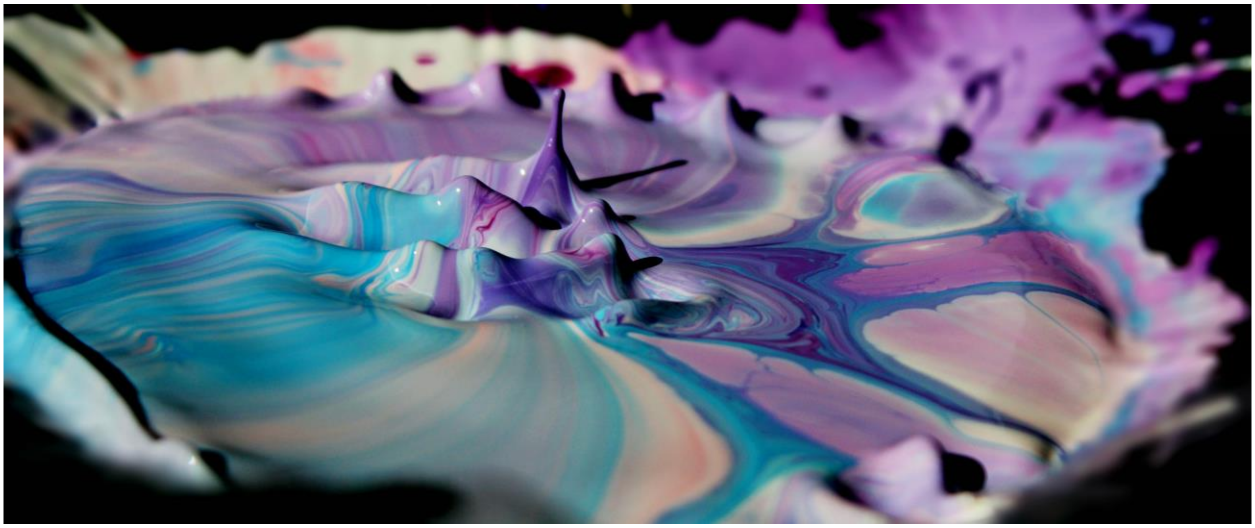

Figure 1: Pain and Food Dye on a Speaker

Image Context

This image shown in Figure 1was created as the first team experiment with Ryan Daniels, Joey Hall, Schuyler Vandersluis, and myself. We used a 9-inch speaker with paint in order to visualize the vibrations that occur when the speaker is excited. Our intent was to excite colored paint, but all that was readily available was white paint. With the addition of food coloring we were able to still visualize this phenomenon with color, but also observe the mixing that occurred through the excitation of the paint which turned out better than we had hoped for. We also intended to shoot against a white background, but achieving adequate amplitude of the waves and focusing were difficult so we opted for handheld shots at an angle down on the speaker.

Flow Apparatus

For this experiment, we set up a 9-inch speaker as seen in Figure 2. The speaker was wired to a stereo behind the box to protect it from any splattering paint. The speaker was lined with saran wrap to protect the speaker and keep the paint contained. An auxiliary cord was used to play sine waves through the speaker from a phone app that could generate various frequencies. Some half-and-half creamer was also used to help provide a less viscous solution from the paint, and it is seen in the photo.

Figure 2: Experimental Setup

The science behind this experiment is known as cymatics. To put it simply, “cymatics is the study of sound and vibration made visible” (Reid, n.d.). This is a broad field of study that can apply to exciting flat plates to view their vibration to visualizing the how fluids react to sound. In this experiment, we chose to visualize the sound through a fluid. The fluid used was latex paint which has a high viscosity. This was apparent when the paint was poured into the speaker and did not separate as is common with water. Playing sound through the speaker made it even more apparent since even full amplitude hardly allowed for any visible waves. There were only ripples. Adding a small amount of the creamer made a tremendous difference allowing for waves to be visible. The frequency in which this photo was taken was around at 20Hz standing wave. This wavelength produced the best size of waves without becoming either breaking into a chaotic mess of plaint spattering or low amplitude waves. In the photo there is a ridge of equal amplitude waves along the back of the speaker and even visible towards the front. These waves resemble a capillary wave similar to ripples on a water caused by the excitation of the speaker. The other waves present, and the focus of the image, are the waves in the center. There appears to be some capillary waves as well, but there is also one wave with a noticeably greater amplitude. This could be due to a couple circumstances. One would be that the waves merely culminated at this point and a capillary wave trying to move from two directions converged on this point and added their amplitude. Another reason could be due to the fact that the speaker has a cone in the center which creates a smaller depth. This is the reason that the capillary waves are visible along the shallow edge and in the center where the cone is present, but the cone could have also created a greater pressure to push the one node higher. Subsequent experiments showed that increasing the frequency decreased the distance between waves, so these waves are an indication of the frequency at which the sound was played. The wavelength at this frequency corresponds to a measure of meters, so the distance is not equal to wavelength—rather it is something else more reflective of the vibration then the actual sound waves.

Visualization Technique

In order to visualize the waves created by the paint and add artistic value, we used red and blue food dye. After several trials, the drops that had been placed closely mixed to from purple areas while some dye remained separated and is visibly blue or red. In order to decrease the surface tension of the paint for better waves we also added a small amount of half-and-half creamer. This matched the white paint but gave the dye something better to mix with and allowed the mixture to become better excited by the sine waves. There was no method to the mixture amounts and drop placement. The creamer was added as the sound was played in order to reach a good wave height, and the dye drops were added randomly. In order to provide adequate lighting for this experiment, we used direct sunlight around 2pm. We had to move the table several times to stay away from infringing shadows and maximize the sunlight. It was important when taking pictures to keep out of the sun as not to cast a shadow on the speaker.

Photographic Technique

This photo was taken at approximately 6 inches from the center waves with a field of view around 8 inches since the 9inch speaker is slightly clipped. The photo was taken on a Canon EOS Rebel T3i DSLR with a focal length of 55mm, aperture of f/5.6, ISO of 200, and shutter speed of 1/4000sec. The low ISO and higher shutter speed were achievable due to a combination of the low aperture value letting in lots of light and the sunlight that was used illuminate the area providing a strong, diffused lighting point. The original photo is shown in Figure 3 with dimensions of 5184 x 3456 pixels. In order to get to the final image in Figure 1, the curves were adjusted in Adobe

Photoshop according to Figure 4 to increase the contrast and make the colors stand out. Next, the levels were adjusted towards the shadows as seen from Figure 5 to Figure 6 in order to make the background darker and increase contrast. An additional lenticular blur was also applied around the circular formation of the paint in order to blur out the background and bring the focus into the center waves. Finally, the image was cropped down to a size of 5184 x 2160 pixels in order to remove the distracting speaker and saran wrap from the top of the image and the slight blur on the bottom of the image. The image was kept at its original width and sized down to its final height in order to focus on the entire field of paint with the splatter on the right side as added artistic value showing the prior chaos of the photo.

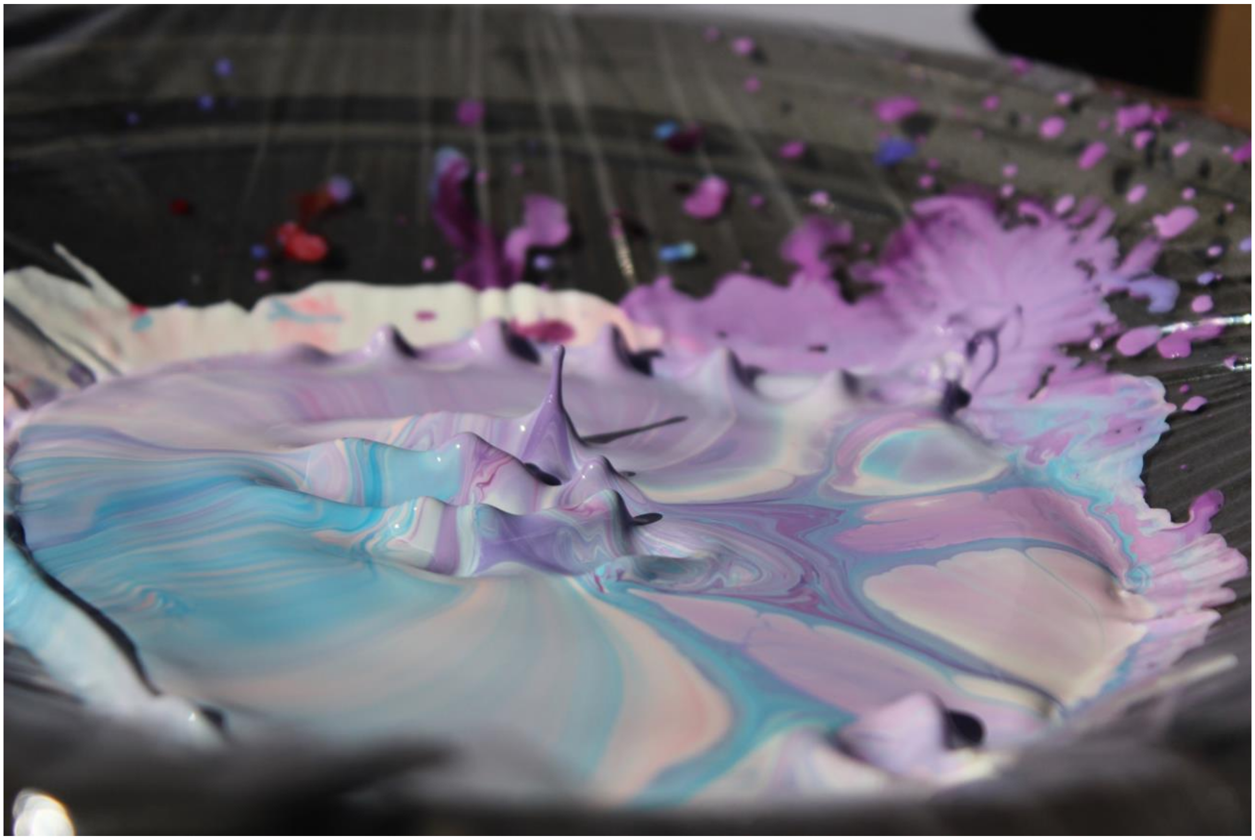

Figure 3: Original Photo

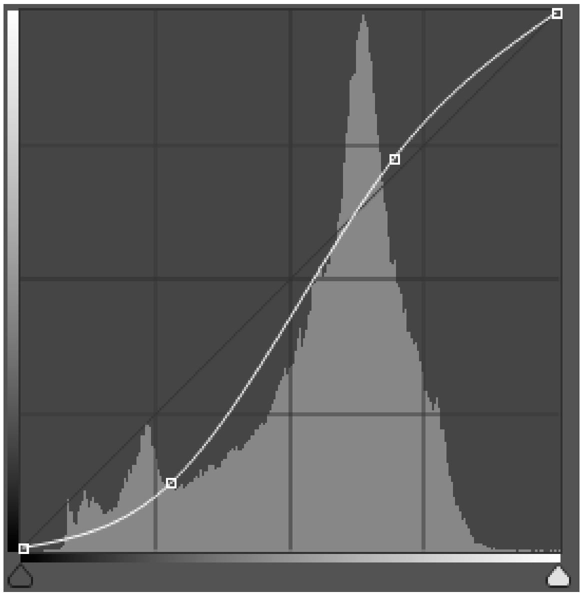

Figure 4: Curves Diagram

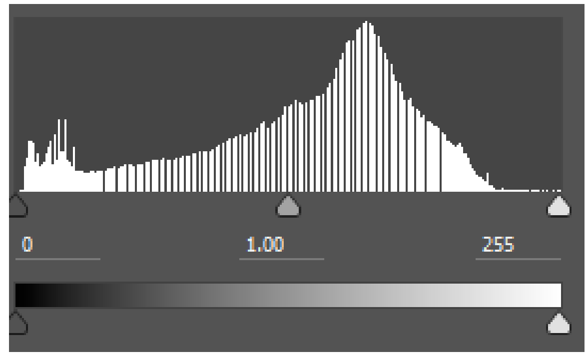

Figure 5: Original Levels

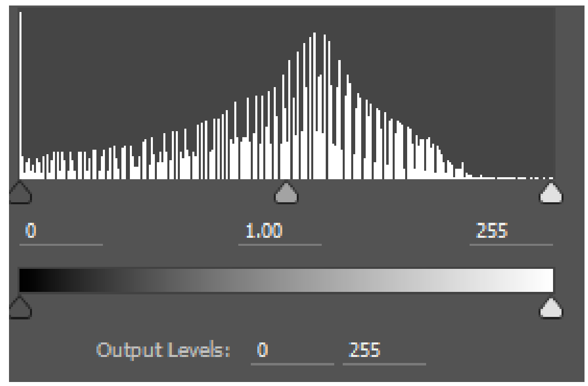

Figure 6: Final Levels

Conclusion

In the end, this image provides a great artistic and physical model of what happens when a low frequency sine wave is played with paint on a speaker. A question remains as to what the relationship is between the frequency and the distance and amplitude of the waves. Additionally, the one larger wave which appears to look like a Worthington jet is an interesting aspect that leaves some uncertainty. To improve this image, it would be great to have a larger speaker for a larger frame to focus on, and a smaller speaker to analyze the difference that size of speaker has on the phenomenon. To develop further, slow motion video would be helpful to analyze the movement and creation of some of the waves.

References

Reid, J. S. (n.d.). Retrieved from Cymascope: http://www.cymascope.com/cyma_research/history.html