Team Second Report

Alexandr Vassilyev

Team Snap Peas: Abhishek Raut, Alexandr Vassilyev, Haotian Chen

MCEN 5151: Flow Visualization

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Context and Purpose

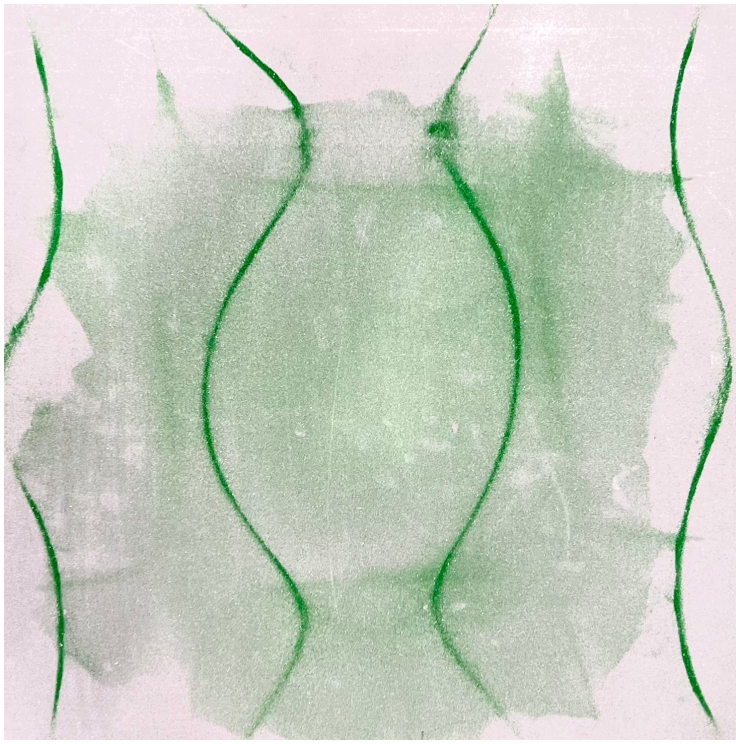

Figure 1: Cymatic formation at 420Hz

Cymatics is the study of how one can visualize sound via vibrational patterns. Sound waves can create geometric shapes and patterns in both solid and liquid mediums. Team Snap Peas (Abhishek Raut, Haotian Chen, and Alexandr Vassilyev) chose to study this phenomenon for the *Team Second* assignment of MCEN 5151: Flow Visualization. The intention was to create an experimental design allowing us to create various patterns at different frequencies, and then to document this through photos and videos. The team worked together, having Abhishek Raut provide materials to create the vibrating platform, with Alexandr Vassilyev and Haotian Chen designing the experimental setup.

Flow Apparatus

The experimental setup used to capture cymatics was quite simple. The materials needed to recreate the experiment were as follows: a speaker, a styrofoam platform, colored sand, and an amplifier. First, the styrofoam must be cut into a square so as to allow the speaker to be placed directly in the middle of it. Next, the styrofoam must be sanded smooth, otherwise sand will become trapped in the pores of the material and not properly form the cymatic patterns. Smoother styrofoam also allows the sand to travel more easily to the antinodes of the frequency being played, meaning the speaker driving the vibrations can be played at a lower amplitude. The step following sanding is to glue a speaker directly in the center of the bottom of the styrofoam square. Not only is this done to have the pattern's midpoint at the center of the styrofoam for a better final photograph, but it also enables the styrofoam to balance on the speaker. This is important as having additional supports for the styrofoam would cause significant interference in the resulting pattern. Finally, colored sand can be placed evenly on the styrofoam. A diagram of this setup is shown below:

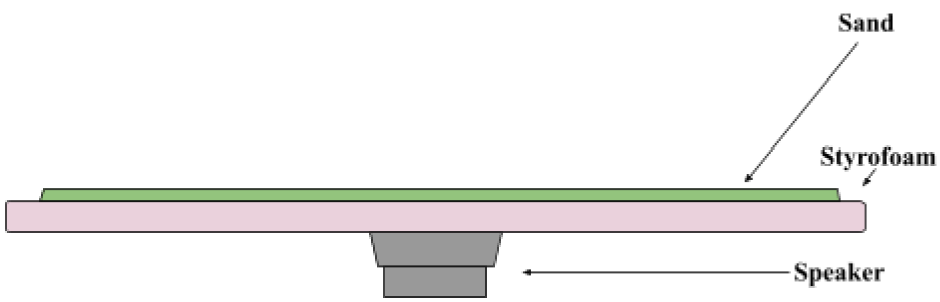

Figure 2: Experimental setup

When a sound is played over the speaker, the displacement caused by the moving air vibrates the styrofoam plate. This resonance imparts energy onto the sand, causing it to move to lower energy areas which are naturally not vibrating as intensely, called anti-nodes. There are a number of factors that can influence the final pattern formed by the frequency, such as the frequency, amplitude, and surface. Spatial resolution mostly relies upon the amplitude (assuming a constant frequency). At a loud amplitude, much more force is applied to the sand, meaning it will displace and form the pattern much more quickly. In this particular case, the formation took roughly 10 seconds at a moderate amplitude. Once the pattern is formed, it remains static. An estimate of the Reynolds number is shown below:

$$Re = \frac{\rho u L}{\mu} = \frac{(Density)(Flow\ speed)(Length\ of\ pattern)}{Dynamic\ viscosity} = \frac{(1800kg/m)(0.1m/s)(1m)}{\sim 6800000\ Pa{-}S} Re = 0$$

A very low Reynolds number would indicate laminar flow, which seems true based on our experimental observations.

Visualization Techniques

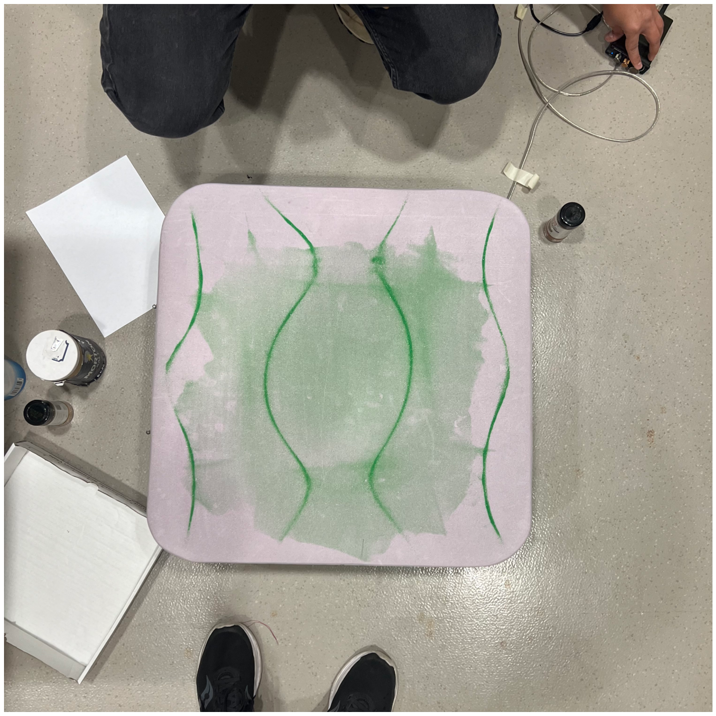

Figure 3: Original unprocessed image

The initial photograph was taken at a height of about 3 feet above the surface of the styrofoam board. The light source was ambient room lighting, producing about 600 nits.

Photographic Techniques

Mild edits were made to create the final image. The color grading was adjusted to highlight the sand located at the antinodes and to reduce the prominence of sand trapped in the pores of the styrofoam in the middle. The white balance was adjusted to compensate for the dim lighting conditions from indoor lighting. Finally, the image was cropped to cut out the floor and supplies shown in figure 3.

Camera information is listed below:

- Camera: iPhone 13 Pro (Editing via Lightroom)
- ISO: 100
- Focal Length: 26mm
- Exposure: f1.5
- Object-to-Lens Distance: 1m
- Image Dimensions: 1462 x 1462px (1:1)

Comments on Image

Overall, I thought that the image was quite interesting, as it was able to effectively capture the effect of sound waves on a physical medium. The dynamic range did a good job highlighting the patterns formed. Most importantly, I enjoyed conducting the experiment needed to capture this image. Being able to observe the cymatic effect while it was occurring live was very impressive. There are a few aspects of the image that I dislike, however. Some of these factors are image quality, as I'm not satisfied with the ability of the final image to show that flow occurred with the sand. I would remedy this in a future experiment by choosing a video as my medium to demonstrate the flow instead. To develop this experiment further, I believe it would be interesting to create a computer program to change the sound frequency on the fly to allow for a continuously changing pattern.

References

Acknowledgements: Team Snap Peas - Abhishek Raut & Haotian Chen

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Reid, Victoria M., and Young, Adam P. "Cymatics: Bringing Sound to Life in the Physics Lab." The Physics Teacher, vol. 51, no. 1, 2013, pp. 30-32.