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Flow Visualization Sec. 001
Assignment: Team Second
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Team Second Report

The Team Second assignment is the second of the team-based assignments, and it gives students a chance to expand on the techniques they've learned in the Team First assignment and experiment with different flow patterns and photography methods. The original goal of our team with this second image was to demonstrate the phenomenon of standing waves in a liquid caused by acoustics. Specifically, a large speaker was to be used to create sound waves, which would create pressure waves within the liquid, with visible peaks and troughs. While after experimenting with different tones we were able to create standing waves, we ended up playing a speaker test tone sequence over the speaker instead, as this created a variation in frequencies and wavelengths of the generated waves in the fluid, which was more interesting visually than simply a standing wave. With slow motion, this effect proved very interesting.

Fig. 1 below shows the test setup. A subwoofer was placed roughly a meter below the surface of a plastic table, on which was placed the glass. The basic flow revealed by the experiment was that the pressure waves created in the air by the subwoofer were translated into vibrations in the table and the glass, which created pressure waves in the water inside the glass with the same base frequency as the tone being played on the speaker [1]. As the test tone was played, the frequency of the waves generated in the water slowly decreased. This created a changing visible transverse wave pattern with nodes and antinodes visible on the surface.

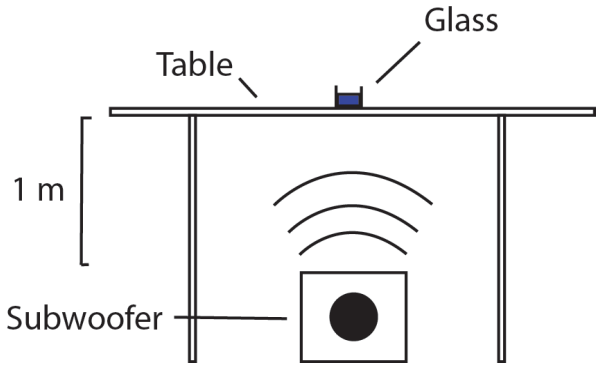

Figure 1: Experimental Setup

The glass used in the experiment contained about 4 oz of water. It also contained false ice cubes, which may have affected the resonance pattern in the water. The sound wave exiting the speaker was likely transmitted to the water while conserving about the same fundamental frequency. However, the wave pattern visible on the surface is actually a superposition of many different frequencies or "harmonics", as can be seen in Fig. 2 below. As the tone played on the speaker changed, these harmonics shifted, causing "nodes" and "antinodes" (in other words, the peak and trough of the waveform, respectively) caused by interference, which can be seen in the video as they shift and dance across the surface [2].

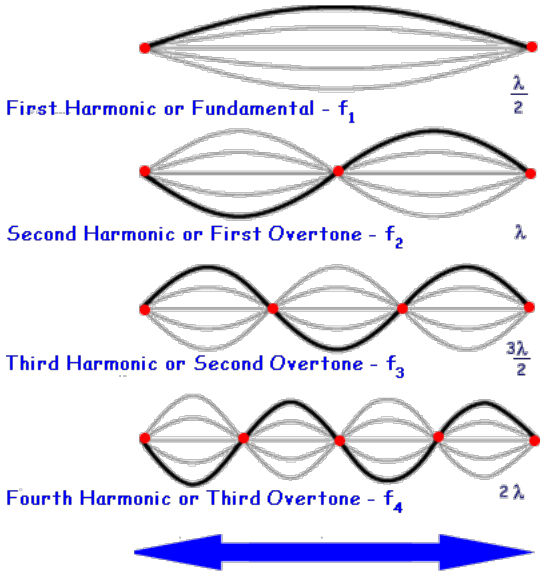

Figure 2: Harmonics and Standing Waves

To visualize the flow, blue and red food dyes were added to the water. Lighting was provided by stage lights, which cycled between red, blue, yellow and red. The yellow setting provided the clearest visualization of the flow, with the most contrast between the yellow lighting and the bluish purple water.

To take the image, the built-in camera on a Samsung Galaxy Note 5 was used. The slow motion setting on this camera captures at 120 fps in 720p quality. To edit the video, iMovie was used as the primary editing software. In iMovie, the video was slowed down to 0.75 of the original slow-motion framerate captured by the camera. A short intro clip showing a turntable was added to the beginning of the footage as well as a title slide, and free music was added using the YouTube royalty-free music feature. The song used was Finding Me by Eveningland.

My goal for this project was to demonstrate the harmonics visible in a glass of water using a subwoofer. It is a very interesting effect that can be seen to a lesser extent in any beverage or container of liquid when loud music is being played. While originally I tried to capture the waves with a still image, I also took a slow-motion video just to see what it would look like and it ended up being much more interesting in my opinion than a still image would have been. The slow motion allows the viewer to really see the constructive and destructive

interference between the waves shift as the frequency changes. For this reason I feel like my artistic vision was realized. If I were to repeat the experiment, however, I would have kept the lighting consistent with only the yellow light for better clarity. I also would have sourced a high-quality high speed camera to capture better quality slow motion video.

Works Cited

1. Scott, A. (2006). *Encyclopedia of Nonlinear Science*. Florence: Taylor and Francis.

2. Johnson. (n.d.). 4.5 Standing Waves - Mr. Johnson's Classes. Retrieved May 6, 2018, from https://sites.google.com/a/morgan.k12.ga.us/mr-johnson/ib-physics-1/topic-4/4-5-standing-waves