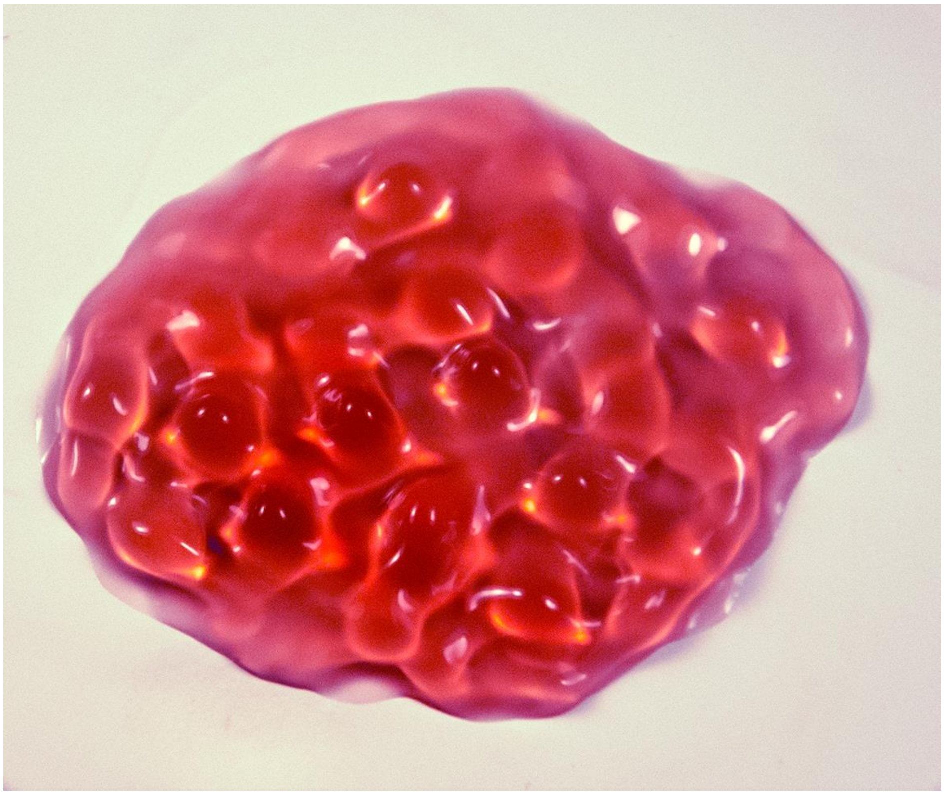
# Team Second Image, Spring Semester 2018



Julian Claudio

MCEN 5151

9 April 2018

University of Colorado, Boulder

# I. Purpose

The purpose of this image is to demonstrate how sound waves create harmonics by vibrating an elastic balloon with water on the top. The water is showing the frequency of the sound wave that is travelling through the air. The sound vibrates the elastic surface, which disturbs the water. The water was a bright red and was set on a white balloon to give a sharp contrast for the image; this is to make it easiest to observe the phenomenon.

# II. Setup and Flow Physics

I setup the experiment by cutting out the bottom of a metal tea can, cutting a plastic balloon, and then mounting that on a Bose SoundLink Mini speaker. Then I dyed water and placed that on top of the balloon. I then played an 80 Hz frequency noise. The setup is pictured below, as well as a diagram below.

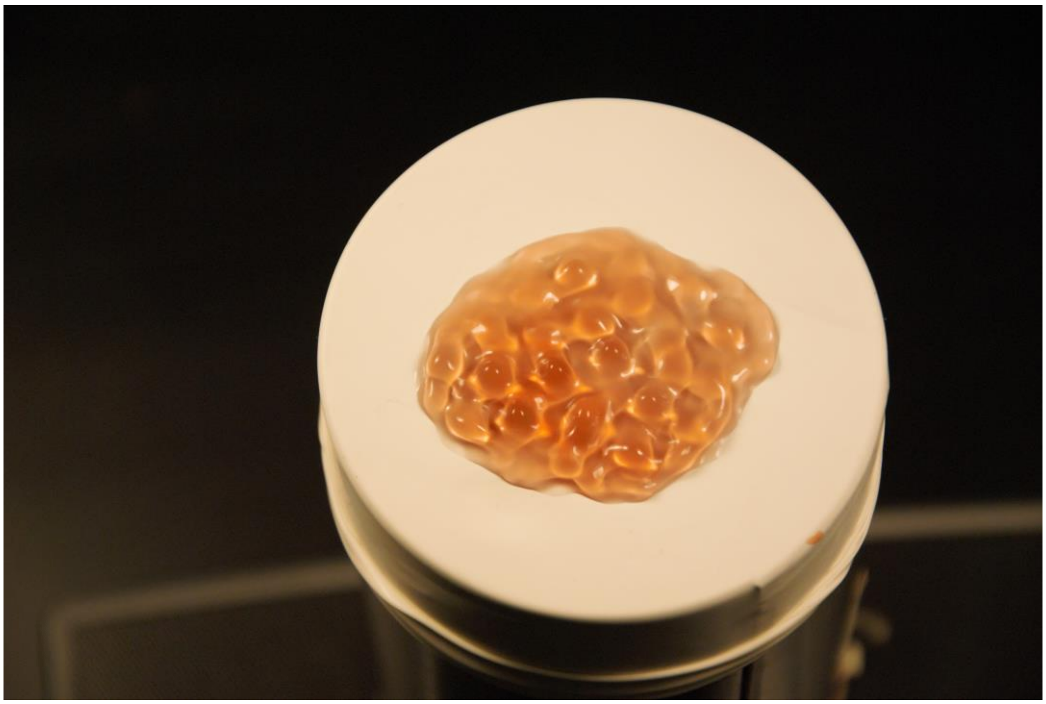


**Figure 1.** Unedited photo, you can see the speaker at the bottom, and the balloon wrapped around the top of the metal cylinder.

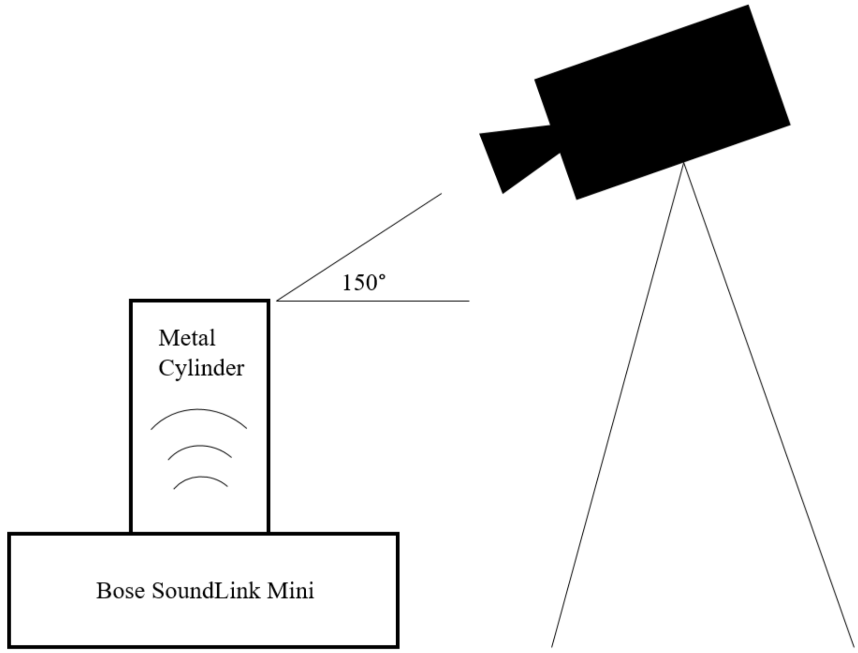



**Figure 2.** Diagram of the setup. The Bose plays a low frequency noise, which then vibrates the balloon and shakes the water.

The frequency from the speaker is played for a few seconds. Sound travels as a wave through the air since the noise is all of the same frequency, this creates a standing wave. The wavelength is determined by the equation.

$$f = v/\lambda$$

Where f is the frequency of the sound wave, λ is the wavelength, and $v$ is the speed of sound. The speed of sound is constant, 640 meters per second, so using this we can determine the wavelength of the sound. The sound waves that I played were at 80 Hz, or 80 waves per second, which gives a wavelength of 8 meters. This is obviously not what we see in the water. Let’s do some analysis of the image to estimate the size of the wavelength observed in the water.

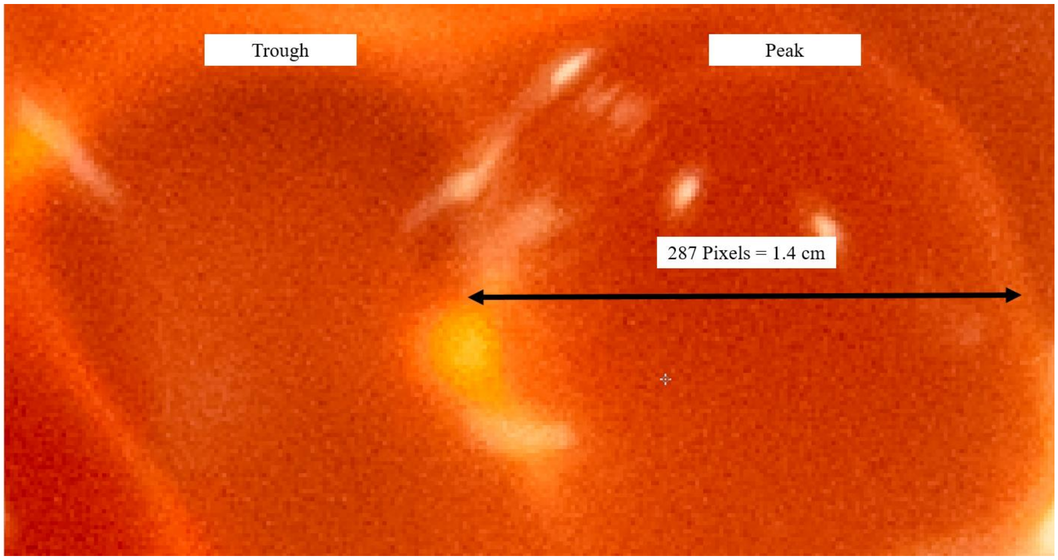



**Figure 3.**

The diameter of the metal cylinder is 3 inches and spans 1526 pixels. This means that the rough size of the peak in the water is .014 meters, or 1.4 centimeters. In total, the peak and the trough make a wavelength of 2.8 cm, since the full wavelength is two times the size of the peak. This is much smaller than the predicted wavelength of sound. Why is this? The answer is that the wavelength of the sound is not actually determining the wavelength of the peaks on the balloon. The sound made the balloon vibrate in resonance, meaning that the balloon is vibrating at natural frequency. The frequency of the sound created what is called a harmonic in the balloon, the balloon was vibrating uniformly along its surface. [2] This is why we can see the distinct peaks and troughs in the water. So, even though the sound has a long frequency, the resonance of the elastic balloon material is what causes the wavelength.

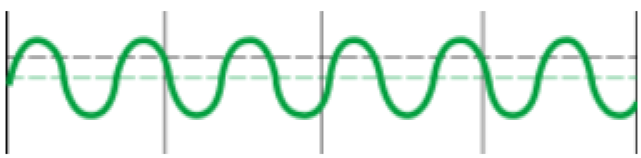


**Figure 4.** A harmonic standing wave. [3]

The balloon surface of the balloon looks somewhat like the wave shown in figure 4, which is what the picture tried to capture.

## III. Visualization Technique

Water was the easiest medium to use to show the waves that were formed from playing the tone. The dye provided a sharp contrast against the white balloon to make the images more bold and interesting to look at. I had lighting setup directly above the cylinder so that the image would be bright, since the shutter speed was relatively fast (1/250.)

# IV. Photographic Technique

The image was taken on a Nikon D3000 mounted on a tripod and was at about a 150-degree angle measured from the ground. The shutter speed was 1/250 and the aperture was f1.4 and an ISO of 1600. I mounted the camera on a tripod and put it at an angle of 150 degrees so that I could get better shadows in my lighting. From directly above was harder to see the peaks and troughs of the waves. I chose a fast shutter speed to make sure that there was a crisp and clear image, since the waves were forming very quickly, and the 80 Hz sound was only played for 2 seconds.

# I. References


[1]: Strings, standing waves and harmonics. Dr. Joe Wolf, University of New South Wales. https://newt.phys.unsw.edu.au/jw/strings.html

[2]: The Vibrations of Bubbles and Balloons. Dr. K A Kuo and Dr. H E M Hunt, University of Cambridge. https://www.acoustics.asn.au/journal/2012/2012_40_3_Kuo.pdf

[3]: Electrical System Harmonics. Dr. Joseph A Butts, Stack Exchange. https://electronics.stackexchange.com/questions/312478/electrical-system-harmonics