Team First Report

MCEN 4151-001

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10/14/2019

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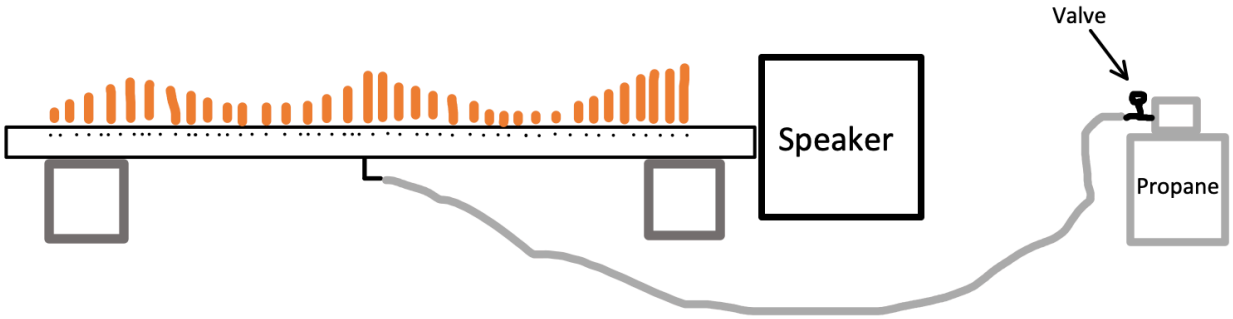
For our first team project we wanted to visualize the different air pressures within a tube caused by sound waves. To do this we built a Ruben's tube and used propane as the working fluid to display the varying pressures. Aaron Zetley picked up the building materials from Home Depot, Evan Blake brought his speaker, and we all contributed to building and setting up the experiment

The Ruben's tube was constructed using a 5' length of 3" galvanized steel ducting. 1/16" holes spaced 3/4" apart were drilled along the top and a 3/8" hole was drilled in the side for the tube fitting. Rubber tubing was used to carry the propane from the tank to the Ruben's tube. A balloon was cut and stretched over one end of the ducting to create a diaphragm. Aluminum tape was used to cap the other end and seal any potential areas for leaks. The Ruben's tube was placed on cinderblocks to raise it off the ground and a large speaker sat about 1/4" away from the balloon end. The valve was used to control the flow rate. Lower flow rates produced smaller and more uniform flames while higher flow rates led to taller, wispy flames that were more sensitive to the wind.



While taking the picture, the flow rate of the propane was kept constant. A "C" note was played through the speaker producing standing waves in the Ruben's tube. The force from the standing waves create areas of varying pressure. The pressure is highest where the flames are the tallest and the areas of low pressure are where the flames are short. The frequency of the "C" note played can be calculated from this image by dividing the speed of sound by the wavelength. There are 17 flames from peak to peak spaced 3/4" apart leading to a wavelength of 12.75" or 0.324m. Provided the speed of sound in propane is 258m/s [1], the frequency of the sound and waveform shown in the flame is 796Hz.

All of the materials used to build the Ruben's tube were purchased from Home Depot. The 5-gallon propane tank used was from a gas grill. A black backdrop was placed behind and under the Ruben's tube to minimize distracting elements in the photo. We performed this experiment on the lower patio of the ITLL because it was protected from the wind and nothing flammable was in the area (other than the propane). The photo was taken at dusk and no additional lighting was used.

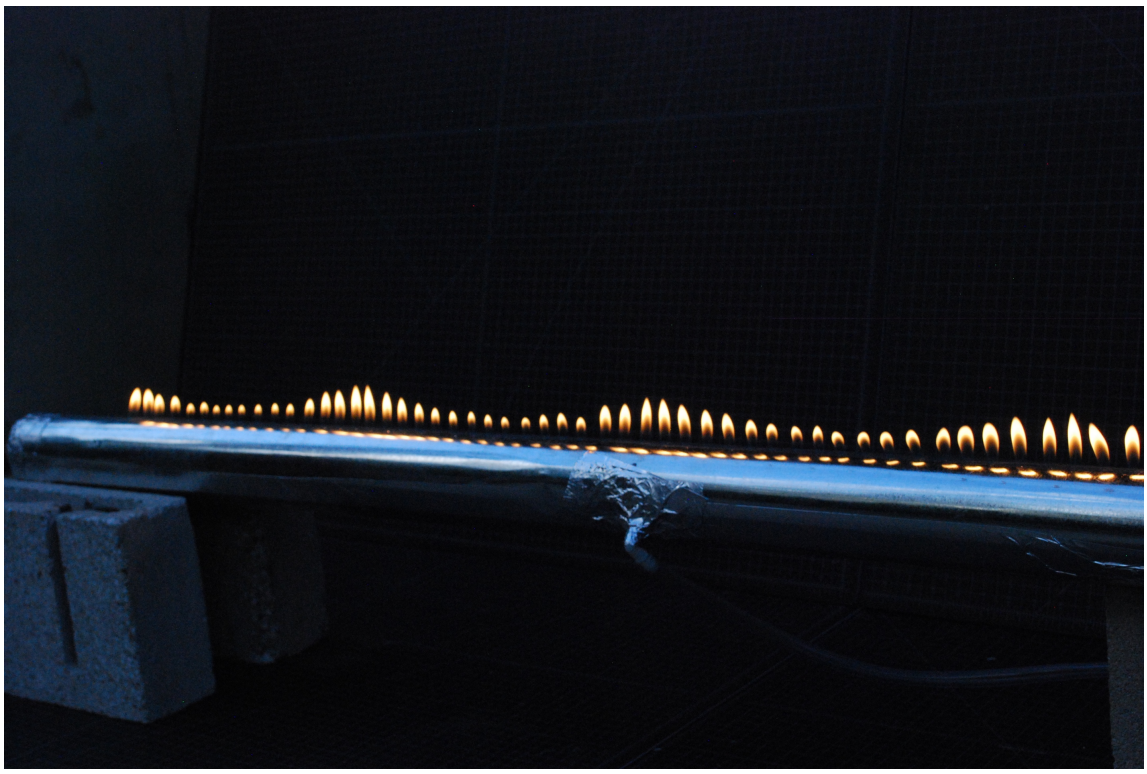


Figure 1: Original image 3872x2592 pixels

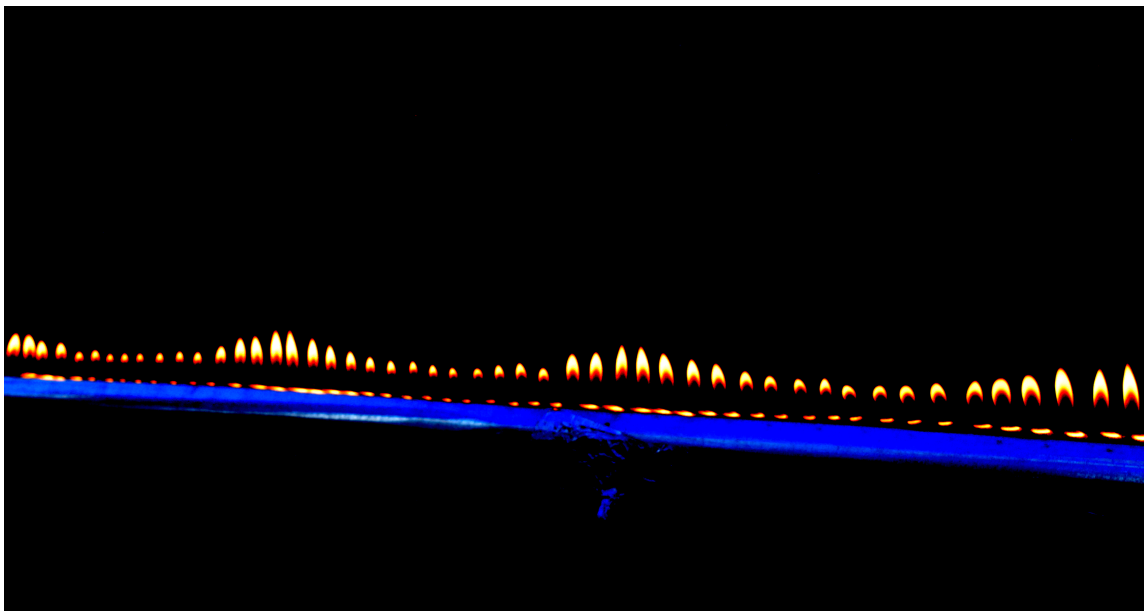


Figure 2: Edited image 3229x1710 pixels

After taking well over one hundred pictures with different camera settings, flame heights, and sounds from the speaker, I went with this image because of the clarity of the waveform. The field of view was found to be 37.5” since there are 50 flames across the image spaced 3/4" apart. The lens was about 3’ from the flames when the picture was taken. The lens I used was a Nikon DX AF-S NIKKOR 18-55mm 1:3.5-5.6G and the focal length for this image was 36mm. The camera used was a Nikon DSLR D60 with an aperture of f/7.1, shutter speed of 1/500, and ISO

of 1600. To edit the photo, I used pixlr.com. I cropped the image as well as increased saturation, decreased brightness, and increased contrast and black to its maximum.

I am very happy with how the image came out. It clearly shows the waveform and frequency of the sound wave. The editing removed background elements and made the flames the obvious focus of the image. I do wish I spent the time to figure out how to remove the tube fitting from the center of the Ruben's tube, but overall I am impressed with how I edited the image. If I were to repeat this experiment, I would make sure there was absolutely no wind present. This would allow for an increase in flame height without them blending together or becoming wispy.

References:

[1] "Handbook of the Speed of Sound in Real Gases," by A. J. Zuckerwar (Academic Press, 2002).