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Sound Pipe

P7-7200

INSTRUCTIONS:

Hold the Sound Pipe at one end and twirl it around. Slowly at first. Gradually increase the rate at which you twirl the tube. Notice what happens.

EXPLANATION:

What makes the Sound Pipe produce sounds? The answer is a combination of resonance and Bernoulli's principle.

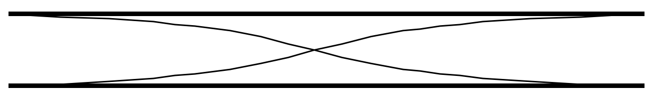
When you twirl the Sound Pipe, the outer end is moving faster than the end in your hand. Bernoulli's principle states that the faster a fluid (like air) moves across a surface the lower the pressure on the surface will be. This explains the reduced pressure at the outer opening of the tube. With higher pressure occurring at the end of the tube held in your hand, the pressure differential results in air rushing up the tube. The faster you twirl the Sound Pipe, the greater the pressure differential, increasing the speed of air moving up the tube. A revealing demonstration of this air motion can be performed by placing the stationary end of the tube over a table on which small torn-up pieces of paper have been placed. Twirling the outer end of the Sound Pipe will vacuum up the paper off the table, spraying it out the other end.

Turbulence is created when air travels through the tube. This turbulence is compounded by the ridges in the sides of the tube. These turbulences produce areas of high and low pressure which when traveling along the tube form the vibrations known as waves. Sound waves traveling out the open ends of the tube partially reflect back into the tube. (Because we can hear the sound outside the tube we know the reflection is not complete.) If the wavelength of the reflected wave matches the wavelength of the incoming wave, these waves reinforce one another, producing sound waves of greater amplitude (sound waves loud enough to hear) and that is what is called resonance.

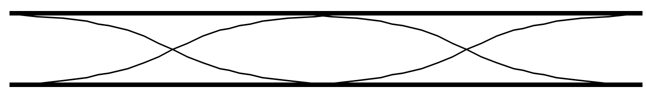
Waves of many different wavelengths are produced, but only waves whose wavelengths fit the length of the tube (or a whole number of half wavelengths) will be reinforced by the reflected waves. The lowest frequency for which the waves resonate is called the fundamental.

As the speed of the air moving up the tube increases, a different set of wavelengths is produced by the faster-moving air. Higher frequencies, related to the fundamental, will also resonate and are called overtones of the fundamental. Since the length of the tube dictates these frequencies, only these select sound waves will be heard. The diagrams below show the different wavelengths that resonate in an open-ended tube.

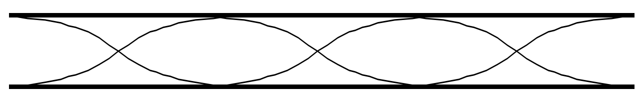
Fundamental Frequency
$L=1/2\,\lambda$ $\lambda = 2L$ $f=f_1$



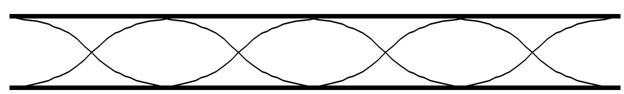
Second Harmonic
$L=\lambda$ $\lambda = L$ $f=2f_1$



Third Harmonic
$L=3/2\,\lambda$ $\lambda = 2/3\,L$ $f=3f_1$



Fourth Harmonic
$L=2\,\lambda$ $\lambda = 1/2\,L$ $f=4f_1$



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