4.5.1: Introduction

A pipe closed at one end will have a natural resonant frequency that is inversely proportional to its length. Such a pipe can support one quarter wavelength. Therefore, its fundamental resonant frequency will be:

$$f = \frac{\nu}{4l}$$

where f is the frequency in Hertz, ν is the velocity of sound in air (roughly 343 meters per second), and l is the length of the tube in meters. Pipes closed at one end will produce an odd harmonic sequence, that is, besides the strong fundamental they will also produce smaller amounts of three times the fundamental, five times the fundamental, seven times the fundamental and so on. These additional harmonics give the pipe its characteristic sound or timbre. Ideally, increased length decreases frequency and the diameter of the tube is inconsequential. In a more precise analysis, the diameter does play a minor role by slightly increasing the effective length of the tube as the diameter grows. The impact of this can be computed via an "end correction factor" which states that the effective length is increased by an additional 0.6 times the pipe's inside radius (.3 times its diameter). For slender pipes this effect will shift the frequency by only a few percent or less.

$$f = \frac{\nu}{4(l + 0.6r)}$$

If excessive force of air is used, it is possible to strongly excite the third harmonic while suppressing the fundamental. The pipe will appear to resonate at three times the frequency predicted by the formula.