

Examples of Harmonics on Pipes and Strings

A closed pipe is 20 cm long. Find the wavelengths of the first 3 possible harmonics on the pipe.

closed pipe: only odds $\lambda_1 = 4L = 80 \text{ cm}$
 $\lambda_3 = \frac{80}{3} \text{ cm}$ $\lambda_5 = \frac{80}{5} \text{ cm}$

A 50 cm long open pipe first resonant (has a harmonic) at 60 Hz. Calculate the speed of sound in the pipe.

open pipe: all harm. $\lambda_1 = 2L = 1 \text{ m}$ $f_1 = 60 \text{ Hz}$
 $v = f\lambda = 60 \text{ m/s}$

Obviously, the fluid in the pipe is not air, which has a speed around 340 m/s. It must be a heavier (or slower) gas, like Sulphurhexafluoride (look it up).

The speed of sound in a pipe is 340 m/s. The pipe is open at both ends and 40 cm long. Find the first three possible frequency on this pipe.

$\lambda_1 = 2L = .8 \text{ m}$ $v = f\lambda$
 $f_1 = v/\lambda = \frac{340}{.8} = 425 \text{ Hz}$ $f_2 = 2f_1 = 850 \text{ Hz}$ $f_3 = 3f_1 = 1275 \text{ Hz}$

A closed pipe has a 3rd harmonic that resonates at 330 Hz. If the speed of sound in air that day is 330 m/s, what is the length of the pipe?

$n = \text{odd's}$ $f_3 = 330 \text{ Hz}$ $v = f\lambda$
 $\lambda_1 = 4L$ $f_1 = 110 \text{ Hz}$ $330 = 110(4L)$
 $\lambda_1 = 4L$

A 60 cm string supports 4 "loops" when vibrated at 42 Hz. What is the speed of the wave on the string?

string: $\lambda_1 = 2L = 120 \text{ cm} = 1.2 \text{ m}$
 4 loops = 4th harm. = 42 Hz
 2 methods:
 1) use fundamental:
 $v = \frac{42}{4}(1.2) = 12.6 \text{ m/s}$
 2) use H_4 : $\lambda_4 = \frac{\lambda_1}{4}$
 so $v = f\lambda = 42(\frac{1.2}{4}) = 12.6 \text{ m/s}$

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