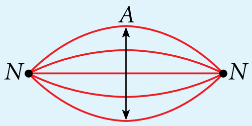
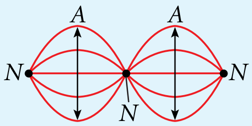
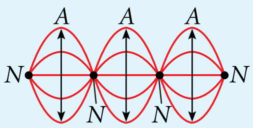
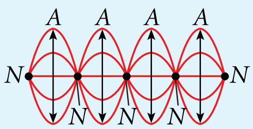
Table 3 The Harmonic Series

	$\lambda_1 = 2L$	f_1	fundamental frequency, or first harmonic
	$\lambda_2 = L$	$f_2 = 2f_1$	second harmonic
	$\lambda_3 = \frac{2}{3}L$	$f_3 = 3f_1$	third harmonic
	$\lambda_4 = \frac{1}{2}L$	$f_4 = 4f_1$	fourth harmonic

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This pattern continues, and the frequency of the standing wave shown in the third row of **Table 3** is three times the fundamental frequency. More generally, the frequencies of the standing wave patterns are all integral multiples of the fundamental frequency. These frequencies form what is called a **harmonic series.** The fundamental frequency (f_1) corresponds to the first harmonic, the next frequency (f_2) corresponds to the second harmonic, and so on.

Because each harmonic is an integral multiple of the fundamental frequency, the equation for the fundamental frequency can be generalized to include the entire harmonic series. Thus, $f_n = nf_1$, where f_1 is the fundamental frequency ($f_1 = \frac{v}{2L}$) and f_n is the frequency of the nth harmonic. The general form of the equation is written as follows:

harmonic series

a series of frequencies that includes the fundamental frequency and integral multiples of the fundamental frequency

HARMONIC SERIES OF STANDING WAVES ON A VIBRATING STRING

$$f_n = n\frac{v}{2L} \qquad n = 1, 2, 3, \ldots$$

$$\textbf{frequency} = \textbf{harmonic number} \times \frac{\textbf{(speed of waves on the string)}}{\textbf{(2)(length of vibrating string)}}$$

Note that v in this equation is the speed of waves on the vibrating string and not the speed of the resultant sound waves in air. If the string vibrates at one of these frequencies, the sound waves produced in the surrounding air will have the same frequency. However, the speed of these waves will be the speed of sound waves in air, and the wavelength of these waves will be that speed divided by the frequency.

Did you know?

When a guitar player presses down on a guitar string at any point, that point becomes a node and only a portion of the string vibrates. As a result, a single string can be used to create a variety of fundamental frequencies. In the equation on this page, L refers to the portion of the string that is vibrating.