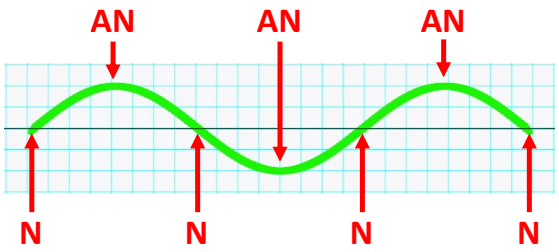
The Harmonics of Vibrating Strings

Video Notes

Standing Wave Patterns

- Each frequency at which a string naturally vibrates is associated with a standing wave pattern.
- Standing wave patterns consist of **nodes** and **antinodes**.



A **node** is a location along the string that appears to be standing still. It is a point of "no-des"-placement.

An **antinode** is the opposite – a point that is vibrating wildly from a maximum positive displacement to a maximum negative displacement.

Harmonic Frequencies and Their Relationships

- One of the frequencies at which a string **naturally** vibrates.
- The lowest-frequency harmonic is the first harmonic or fundamental frequency.
- Other frequency values are whole number multiples of the fundamental frequency

Just an example.

$f_1 = 150$ Hz

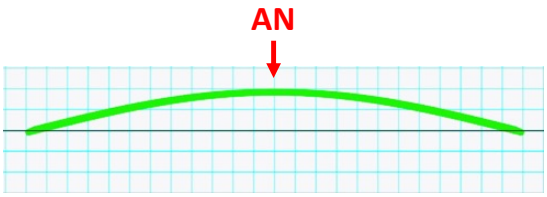
$f_2 = 300$ Hz

$f_3 = 450$ Hz

$f_4 = 600$ Hz

Length and Wavelength Relationships

- The standing wave pattern for the first harmonic has one anti-node and one-half a wavelength in the string.
- The wavelength of the first harmonic is ALWAYS twice the string length.
- Other harmonics have wavelengths that are fractions of this wavelength.



If L = 60 cm, then $\lambda_1 = 120$ cm.

$\lambda_2 = (1/2) \bullet \lambda_1$ $\quad \lambda_2 = 60$ cm

$\lambda_3 = (1/3) \bullet \lambda_1$ $\quad \lambda_3 = 40$ cm

$\lambda_4 = (1/4) \bullet \lambda_1$ $\quad \lambda_4 = 30$ cm

Comparing Patterns, Frequencies and Wavelengths for Other Harmonics

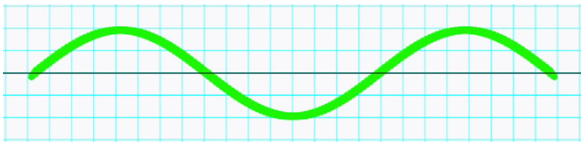
Second Harmonic:

Two antinodes in the pattern

$f_2 = 2 \bullet f_1$ $\qquad \lambda_2 = ½ \bullet \lambda_1$

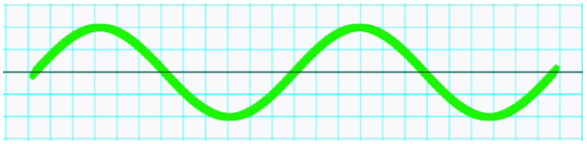
Third Harmonic:
Three antinodes in the pattern

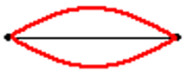
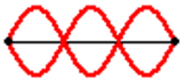
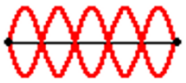
$f_3 = 3 \bullet f_1$ $\lambda_3 = \frac{1}{3} \bullet \lambda_1$



Fourth Harmonic:
Four antinodes in the pattern

$f_4 = 4 \bullet f_1$ $\lambda_4 = \frac{1}{4} \bullet \lambda_1$



Harmonic	Pattern	# of ANs	λ	f	Examples	
					f (Hz)	λ (cm)
1st		1	λ_1	f_1	150	120
2nd		2	$\lambda_1/2$	$2 \bullet f_1$	300	60
3rd		3	$\lambda_1/3$	$3 \bullet f_1$	450	40
4th		4	$\lambda_1/4$	$4 \bullet f_1$	600	30
5th		5	$\lambda_1/5$	$5 \bullet f_1$	750	24
nth	--	n	λ_1/n	$n \bullet f_1$	150•n	1.20/n

Follow along with the video and show the solution for the following two examples.

Example 1

A vibrating string has a first harmonic of 100 Hz. What would the standing wave pattern look like for the same string when vibrating at 500 Hz?

Example 2

A string is 75 cm long. What would the standing wave pattern look like for a standing wave with a wavelength of 50 cm?