Name _____ Hour _____

***Standing Wave: Wave pattern that results when 2 identical waves travel in opposite directions and interfere. Instruments are set into vibration by striking, plucking, bowing, blowing, etc** and vibrate at their natural frequency (resonate) creating standing waves and making music.

Harmonics:

1. Fundamental Frequency: The lowest frequency of vibration for a standing wave that determines its pitch
2. Harmonics Series: A series of frequencies (overtones) that include the fundamental frequency and multiples of it

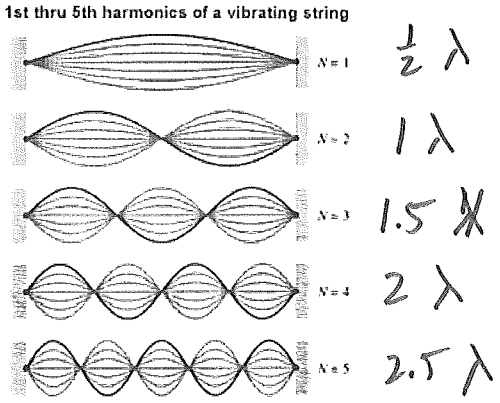
*Notes played are usually a mixture of fundamental and harmonics

2 TYPES OF INSTRUMENTS:

1. **STRING instruments AND pipes OPEN AT BOTH ENDS:**

Examples: guitar, violin, Boomwhacker, piano

Wave has to end in a node



$\frac{1}{2}\lambda$

1λ

1.5λ

2λ

2.5λ

$$f_n = n\frac{V}{2L}$$

$n = 1, 2, 3$

n = harmonic #
f_n = freq of harmonic
V = Speed of sound
L = length of string/tube

A standing wave ending in a node is created every $\frac{1}{2}\lambda$ **wavelength.**

Example 1: Find the fundamental frequency for the spinning plastic tube (length = 0.8 m) if the speed of sound is 343 m/s in the classroom. (≈214 Hz)

$L = 0.8\text{m}$ open both ends!

$V = 330 + (.6 \cdot 21) = 342.6$

$f_n = 1\left(\frac{342.6}{2 \cdot 0.8}\right) = 214\text{ Hz}$

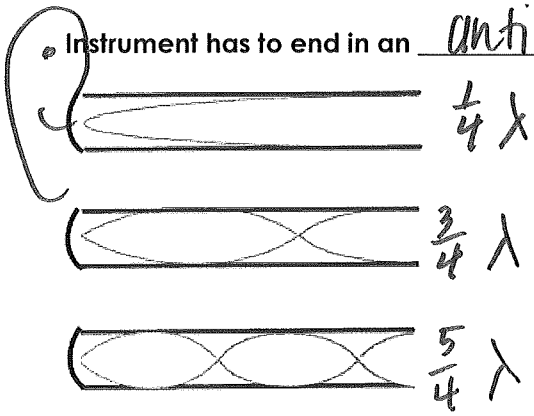
At what frequency would the next harmonic occur? $214 \times 2 = 428\text{ Hz}$

Name _____ Hour _____

2. Pipe CLOSED AT 1 END:

Examples: trumpet, oboe, clarinet, BW with reap

Instrument has to end in an antinode.



$f_n = n\left(\frac{v}{4L}\right)$

$n = 1, 3, 5 \ldots$

A standing wave ending in an antinode is created every odd 1/4 n **wavelength.**

Example 2: What is the fundamental frequency of a 0.20 m long organ pipe that is closed at one end, when the speed of sound in the pipe is 352 m/s? (440 Hz)

open 1 end

$L = 0.2$

$v = 352$ m/s

$f_n = 1\left(\frac{352}{4(0.2)}\right) = 440$ Hz

only odds!

At what frequency would the next harmonic occur? $440 \times 3 = 1320$ Hz

Hmm…how does an instrument like a guitar with only 4 or 5 strings play so many different notes?

hold string in diff. place – changes λ, new fund. freq & harmonics