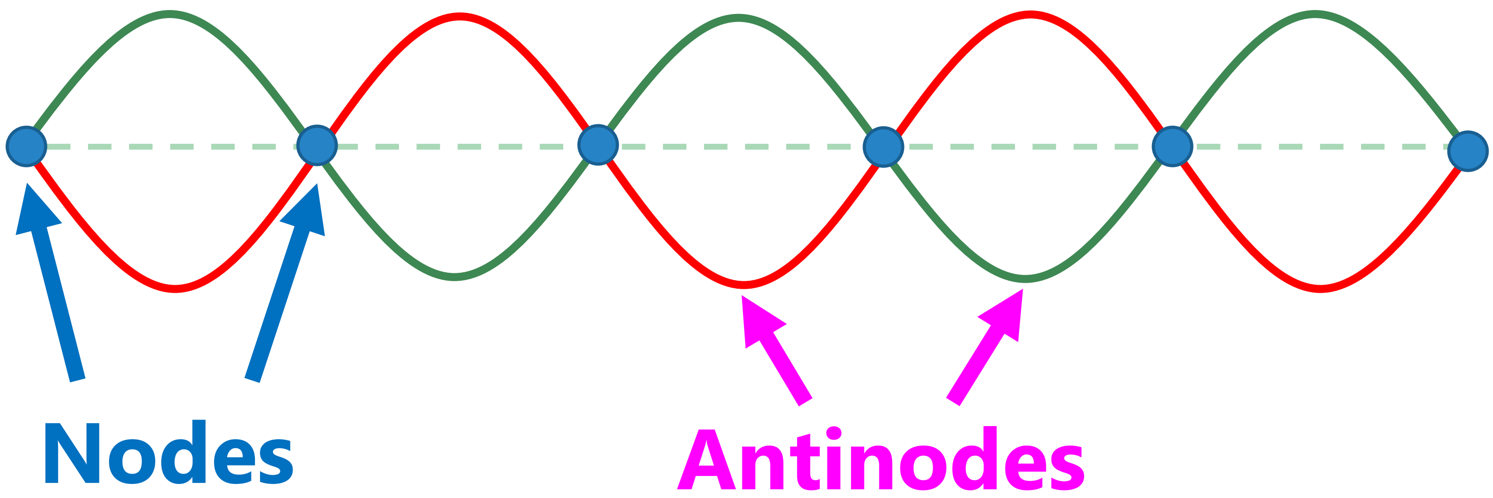
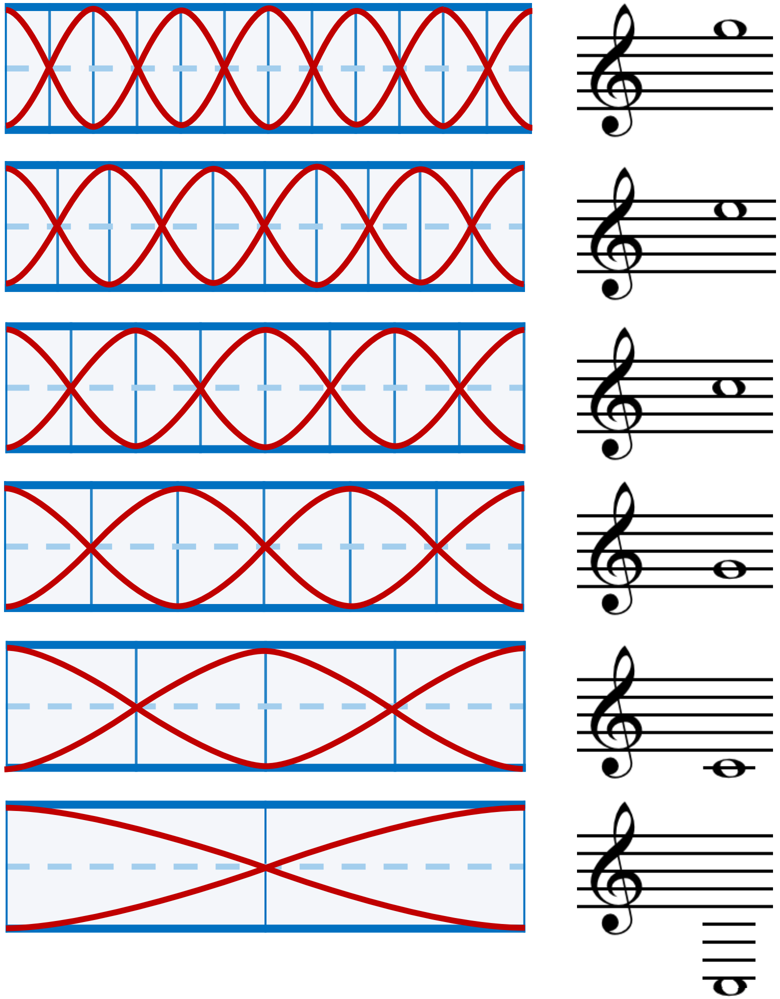
Calculating Harmonics and Instruments

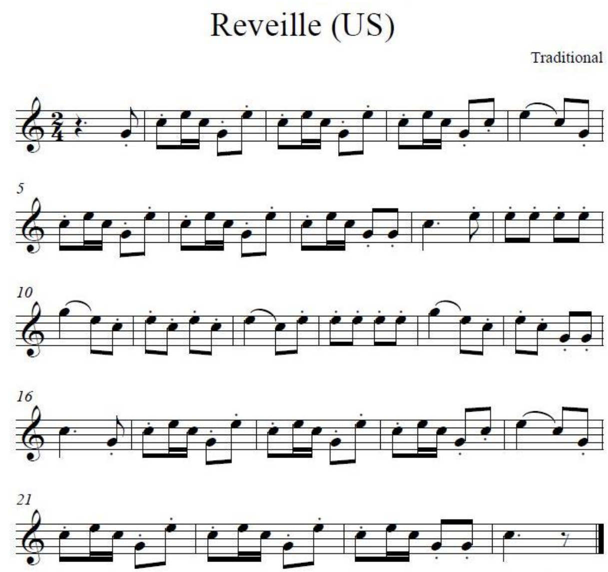
IB PHYSICS | WAVES - SOUND

Standing Waves Review

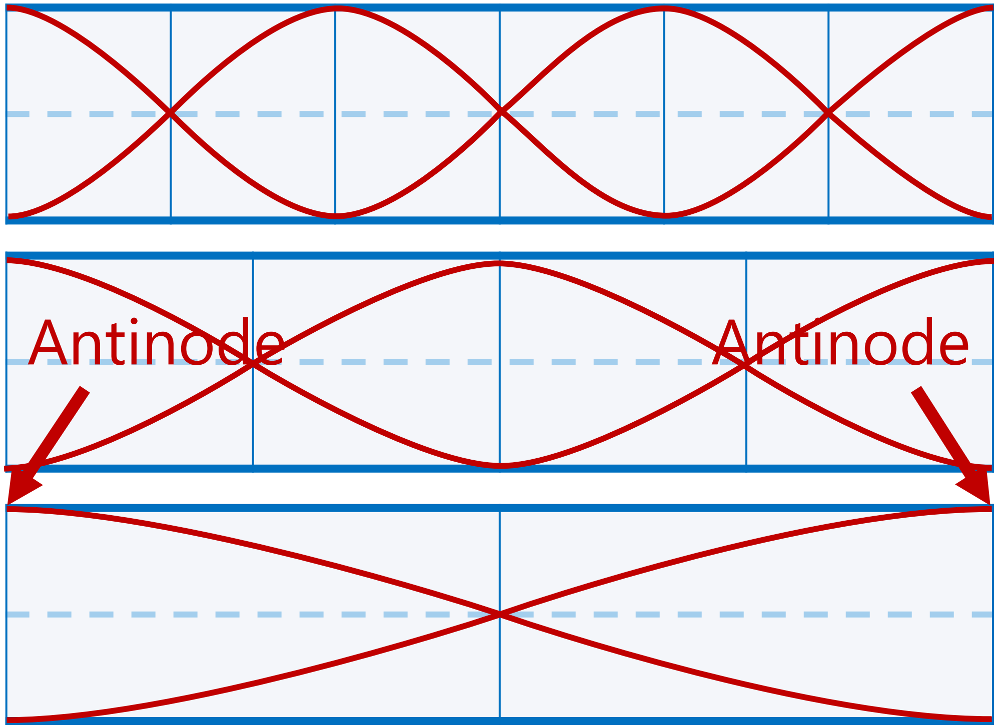


Harmonics



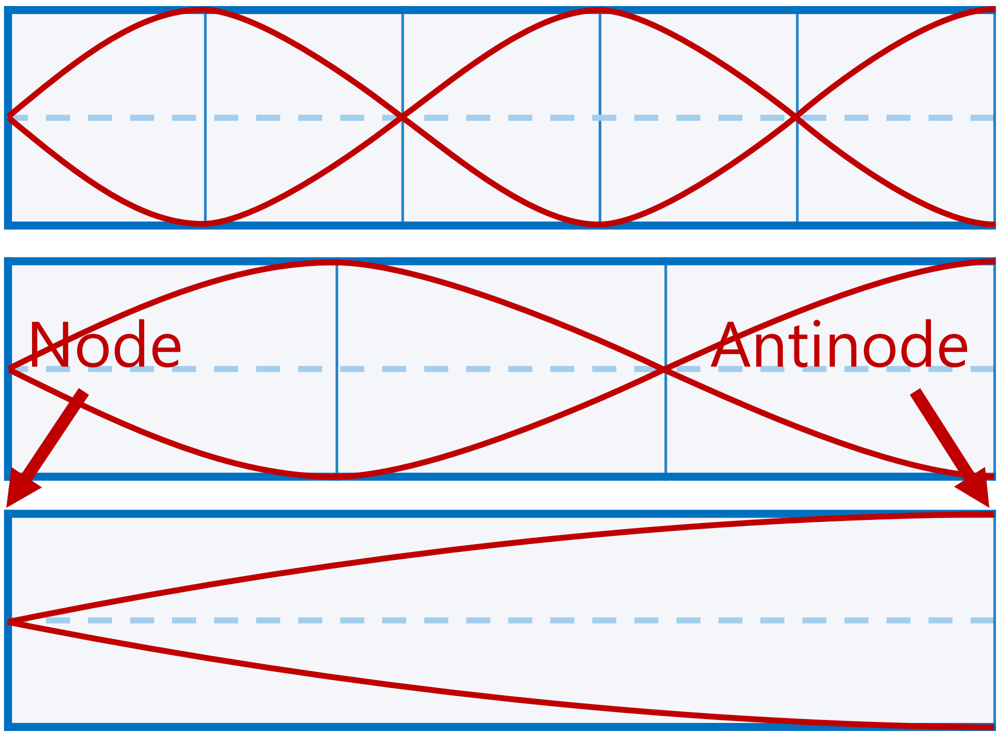


Open Pipe Resonance



L =
$\frac{3}{2}\lambda$
1λ
$\frac{1}{2}\lambda$

Closed Pipe Resonance



L =
$\frac{5}{4}\lambda$
$\frac{3}{4}\lambda$
$\frac{1}{4}\lambda$

Strings make sound too!

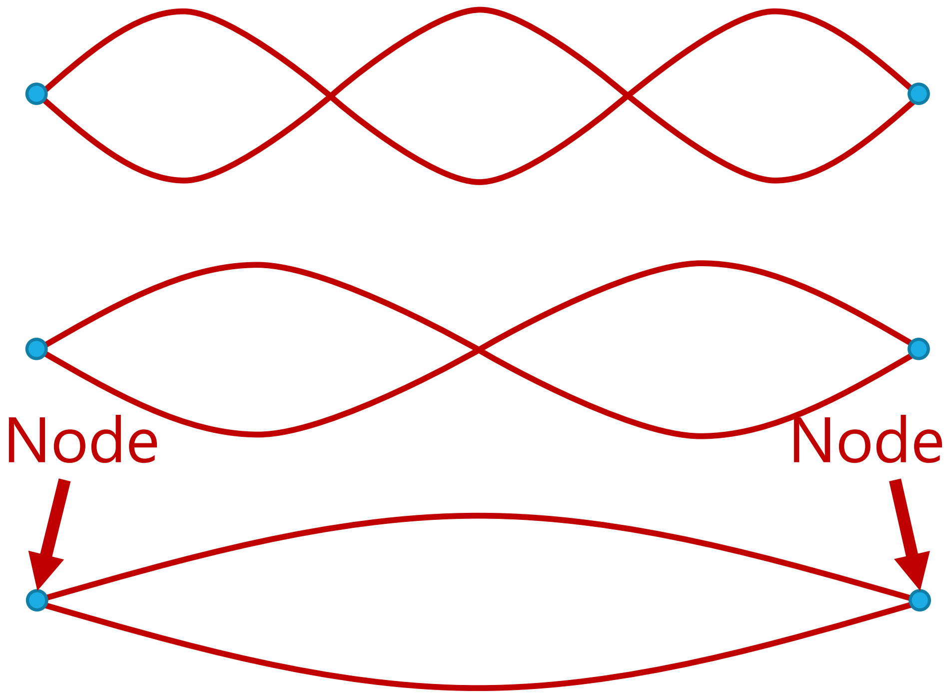
wave speed
____
changes depending on the string tension

Two ways to increase frequency in string:

increase tension

decrease length

String Resonance



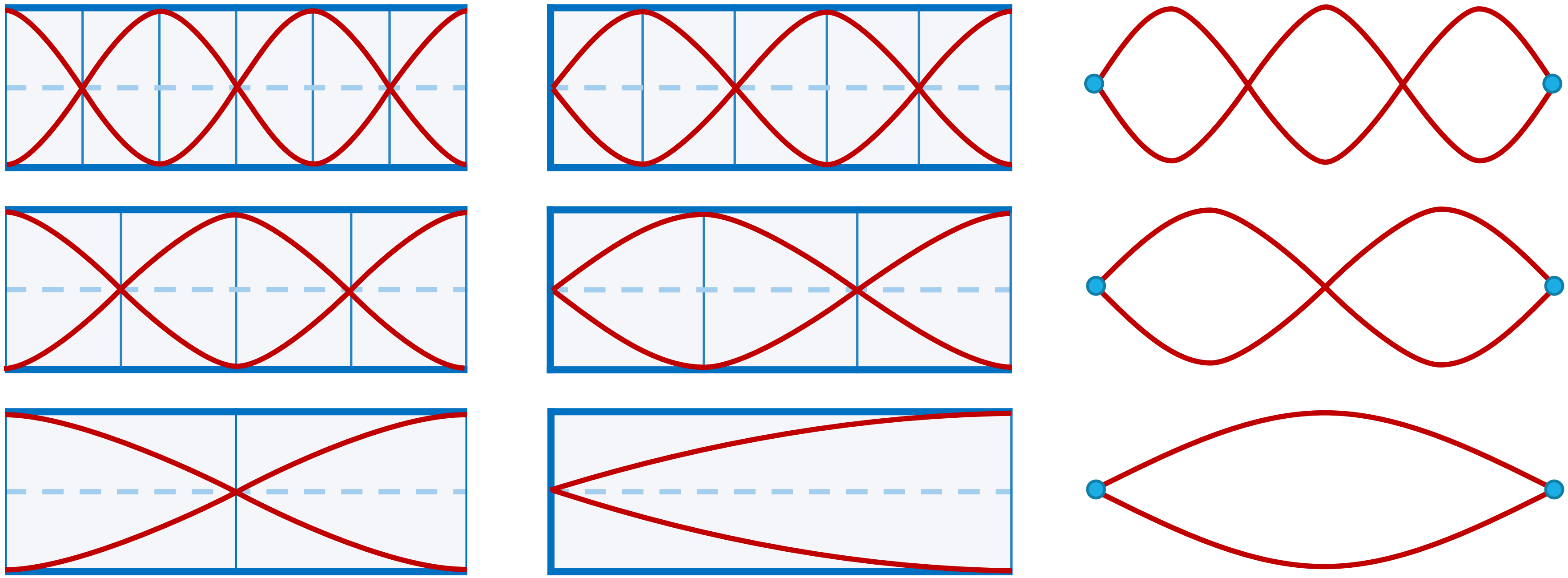
L =
$\frac{3}{2}\lambda$
1λ
$\frac{1}{2}\lambda$

Review of End Conditions

Closed Pipe	Node	Antinode
Open Pipe	Antinode	Antinode
String	Node	Node

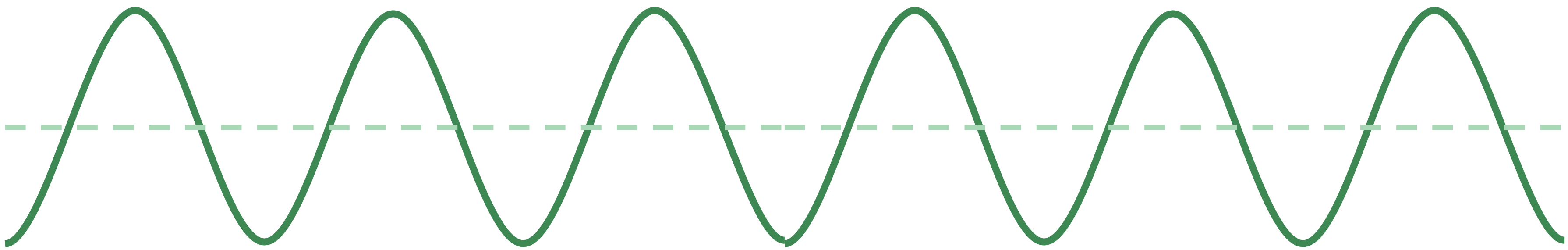
All the Harmonics!

Open | Closed | String

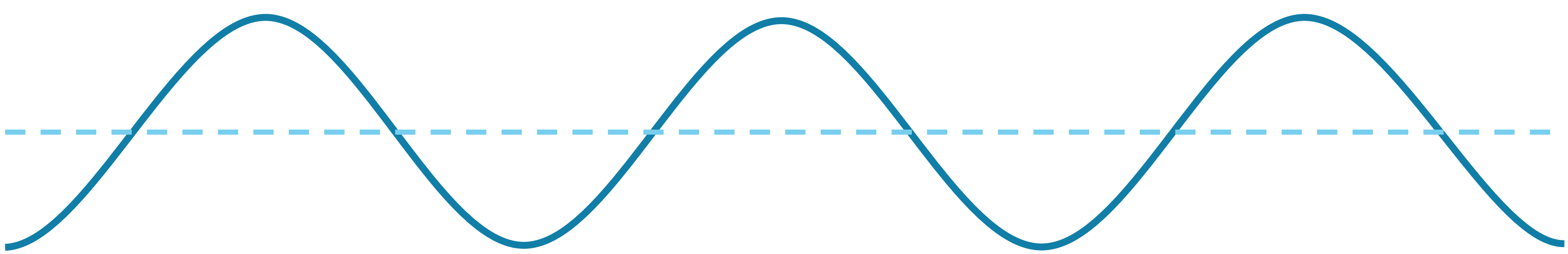


Remember Pitch and Frequency

High pitched sounds have high frequencies

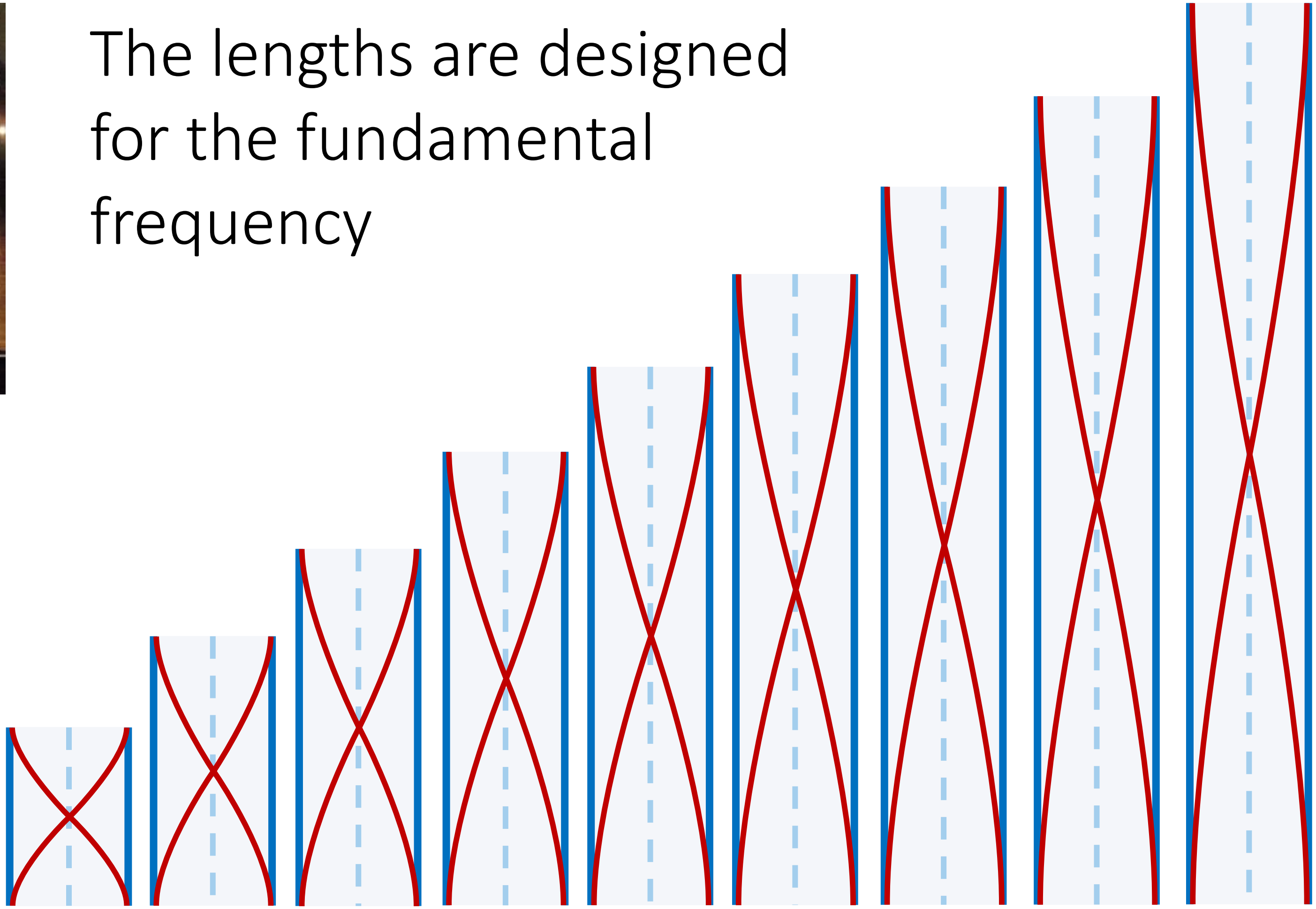


Low pitched sounds have low frequencies

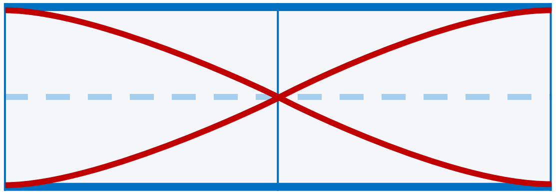


Making Different Pitches

The lengths are designed for the fundamental frequency



Calculating Frequency | Open Pipes



An open organ pipe is 2.1 m long and the speed of sound in the pipe is 341 m/s. What is the fundamental frequency of the pipe?

L (2.1 m)

$$v = f\lambda \rightarrow f = \frac{v}{\lambda} = \frac{341}{4.2}$$

$f = ?$

$v = 341\ m\ s^{-1}$

$\lambda = 4.2\ m$

$$= \mathbf{81.2\ Hz}$$

$$L = \frac{1}{2}\lambda \rightarrow \lambda = 2L = 2(2.1) = 4.2\ m$$

Resonant String Practice

The note produced on a violin string of length 40 cm produces a wave speed of 250 m/s. What is the first harmonic of this note?

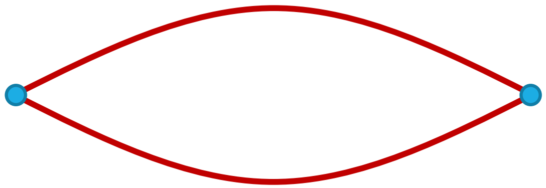
$$v = f\lambda \rightarrow f = \frac{v}{\lambda} = \frac{250}{0.8}$$

$f = ?$

$v = 250\ m\ s^{-1}$

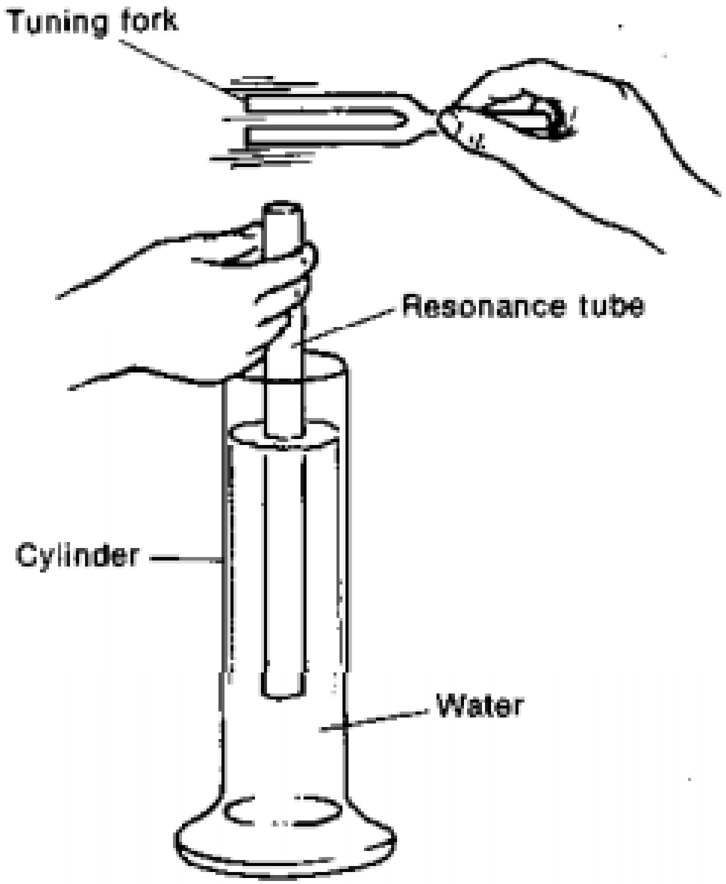
$\lambda = 0.8\ m$

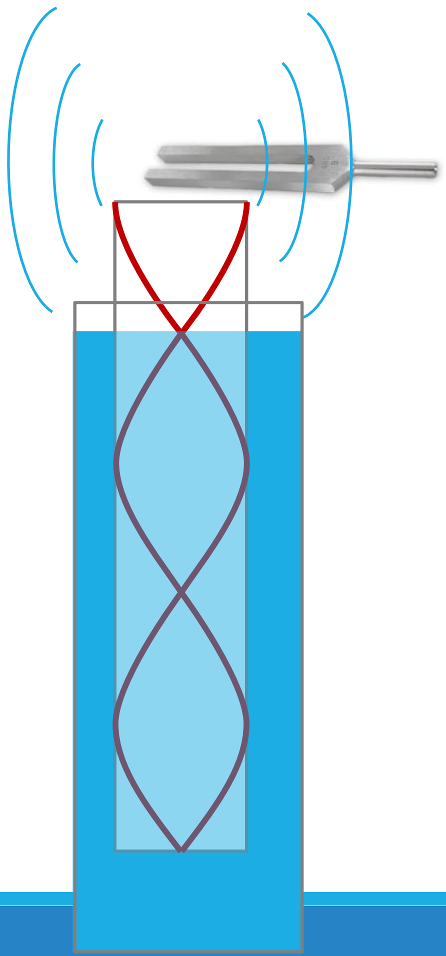
$$= \mathbf{312.5\ Hz}$$



$$L = \frac{1}{2}\lambda \rightarrow \lambda = 2L = 2(0.4) = 0.8\ m$$

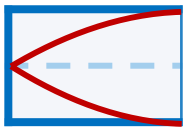
Finding Resonance





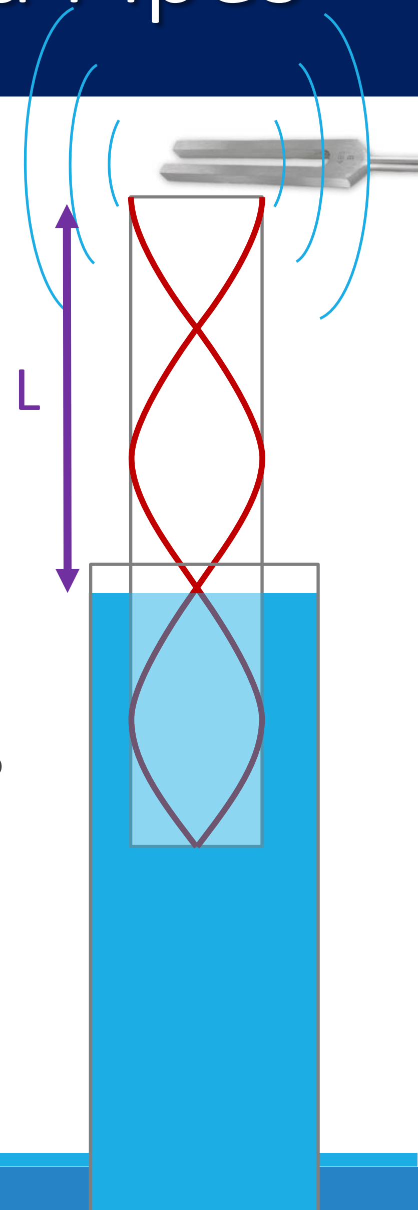
Calculating Frequency | Closed Pipes

You found an unmarked tuning fork in your collection. You notice that the smallest length for resonance is **12 cm**. If the speed of sound is **345 m/s**, what is the tuning fork frequency?

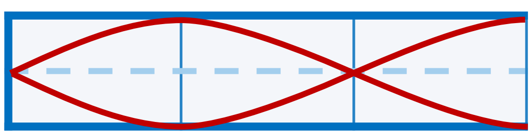


$$L = \frac{1}{4}\lambda \longrightarrow \lambda = 4L = 4(0.12) = \boxed{0.48\ m}$$

$$f = \frac{v}{\lambda} = \frac{345}{0.48} = \mathbf{718.75\ Hz}$$



What should the length of the tube be for the 2nd resonant position?



$$L = \frac{3}{4}\lambda = \frac{3}{4}(0.48) = \mathbf{0.36\ m}$$

Lesson Takeaways

- ❑ I can identify and label the node and antinodes on a standing wave diagram
- ❑ I can describe the end conditions and nodes/antinodes for open/closed pipes and vibrating strings
- ❑ I can calculate the wavelength or instrument length of a standing wave for different harmonics