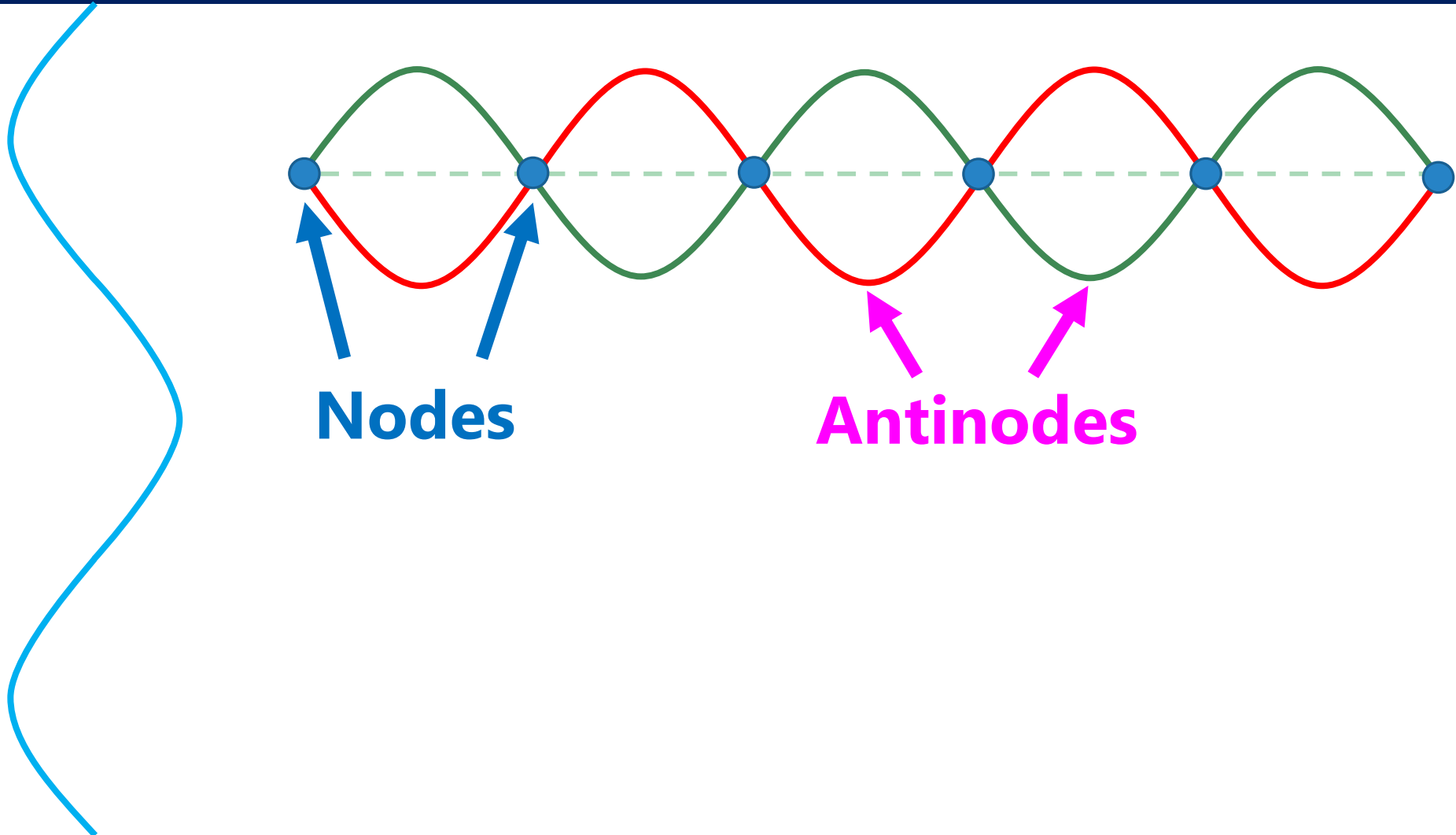


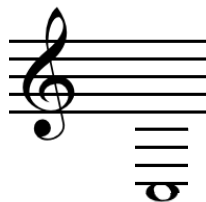
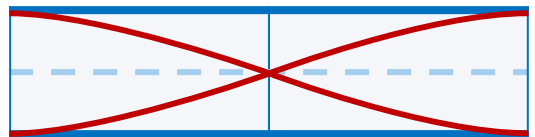
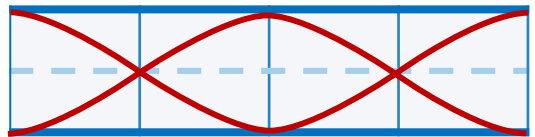
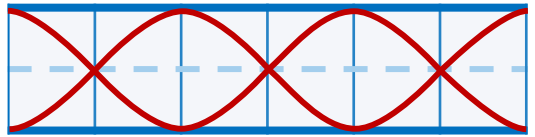
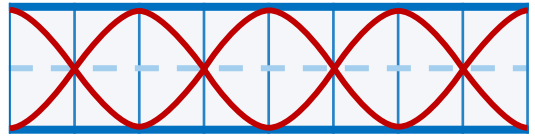
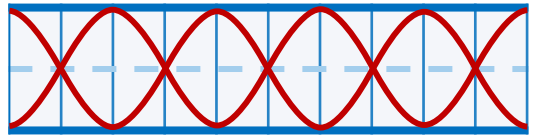
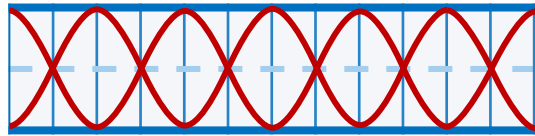
Calculating Harmonics and Instruments

IB PHYSICS | WAVES - SOUND

Standing Waves Review



Harmonics



Taps

$\text{♩} = 40$

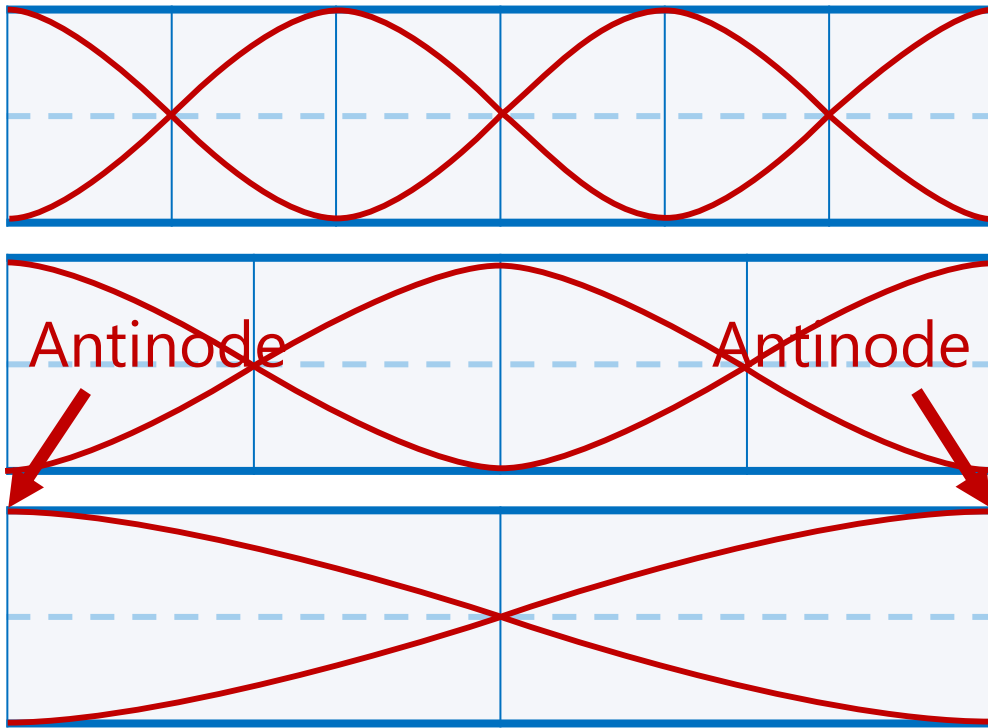
Musical notation for the 'Taps' melody. It consists of two staves. The first staff is in treble clef with a common time signature (C) and contains the melody. The second staff is in bass clef and contains the bass line. The tempo is marked as quarter note = 40.

Reveille (US)

Traditional

Musical notation for the 'Reveille (US)' melody. It consists of four staves. The first staff is in treble clef with a 3/4 time signature and contains the melody. The subsequent three staves are in bass clef and contain the bass line. The notation includes measure numbers 5, 10, 16, and 21.

Open Pipe Resonance



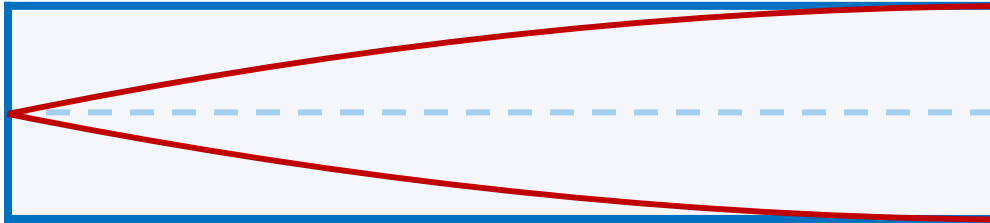
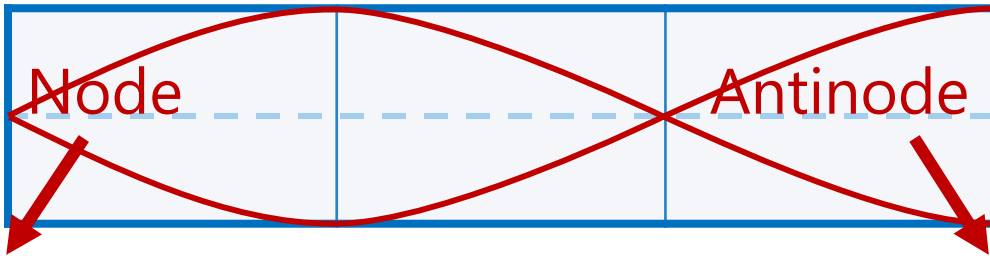
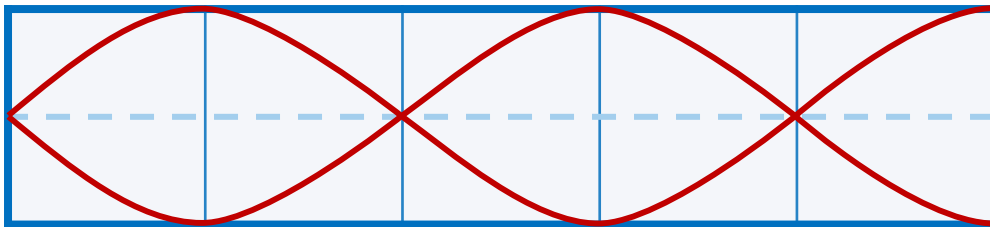
$$L =$$

$$\frac{3}{2}\lambda$$

$$1\lambda$$

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

Closed Pipe Resonance



$$L =$$

$$\frac{5}{4}\lambda$$

$$\frac{3}{4}\lambda$$

$$\frac{1}{4}\lambda$$

Strings make sound too!



wave speed

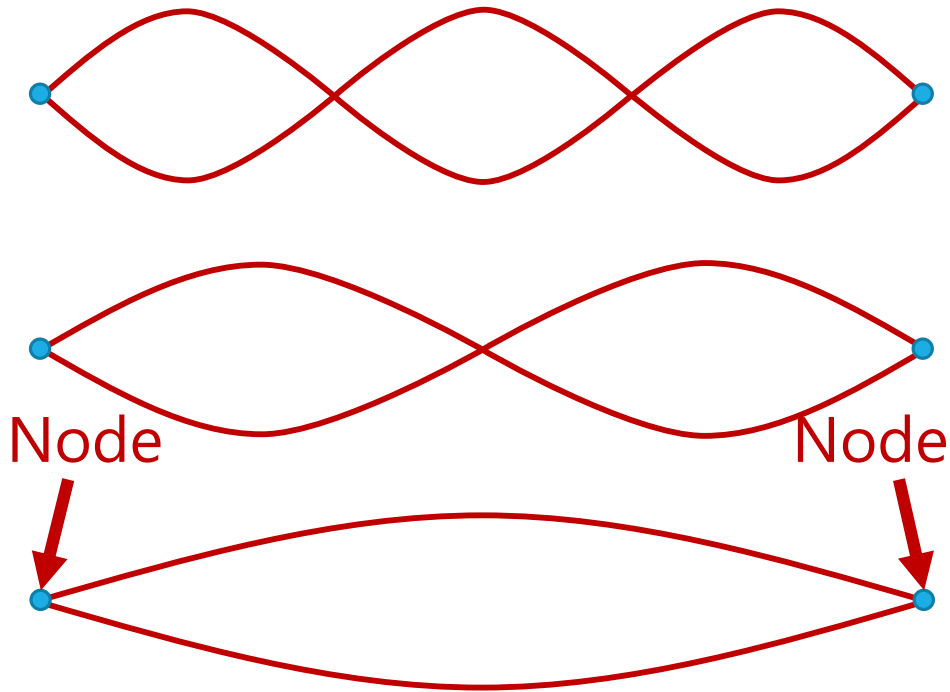
changes depending
on the string tension

Two ways to increase frequency in string:

**increase
tension**

**decrease
length**

String Resonance



$$L =$$

$$\frac{3}{2}\lambda$$

$$1\lambda$$

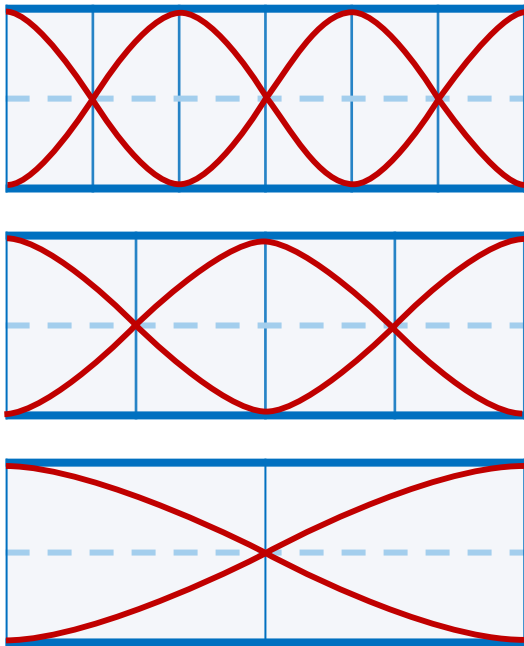
$$\frac{1}{2}\lambda$$

Review of End Conditions

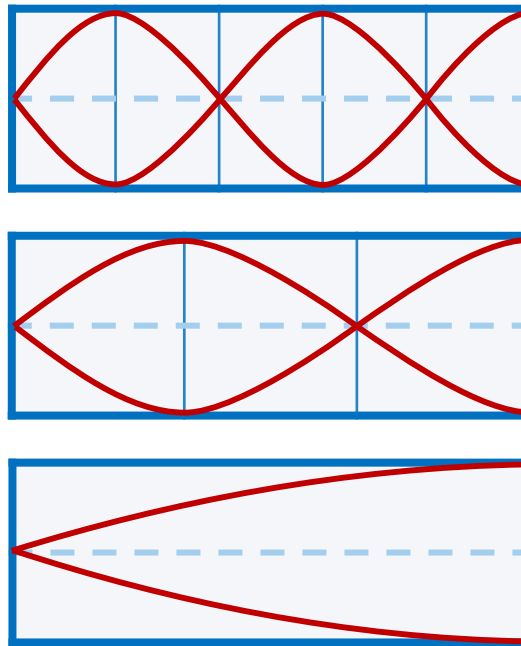
Closed Pipe	Node	Antinode
Open Pipe	Antinode	Antinode
String	Node	Node

All the Harmonics!

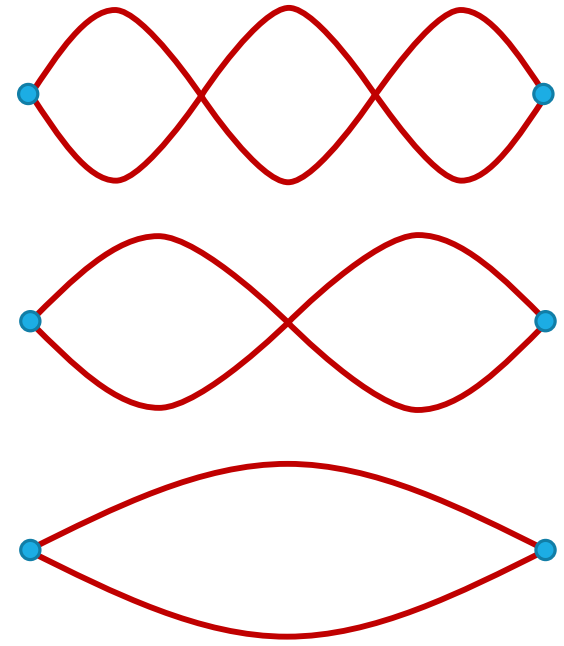
Open



Closed

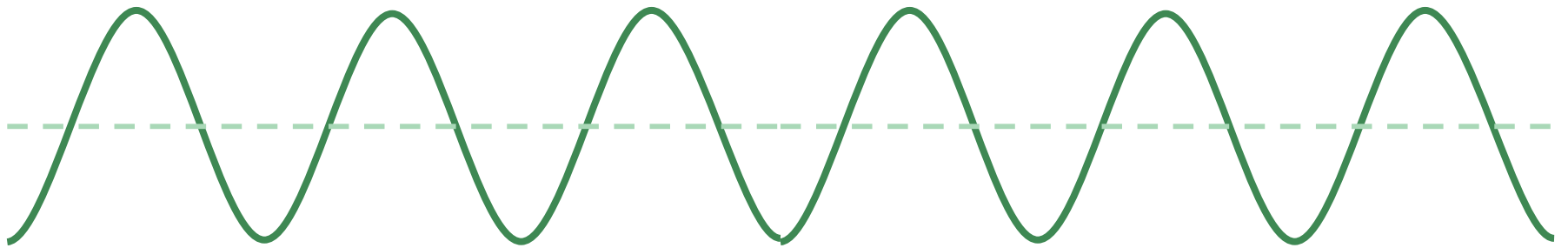


String

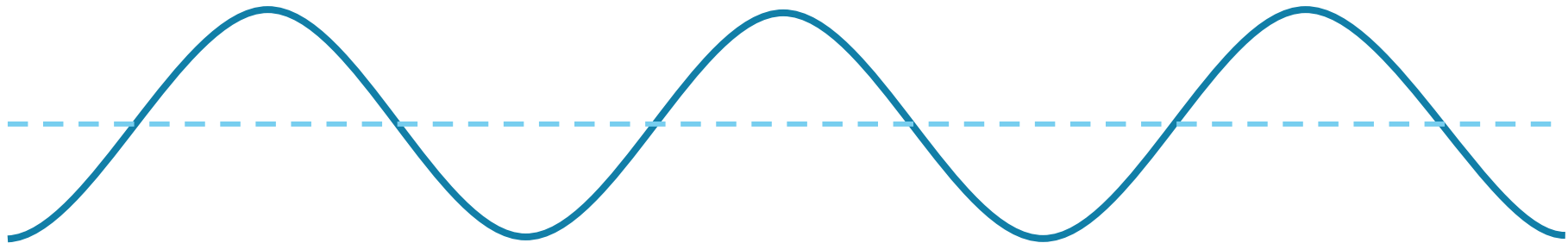


Remember Pitch and Frequency

High pitched sounds have high frequencies



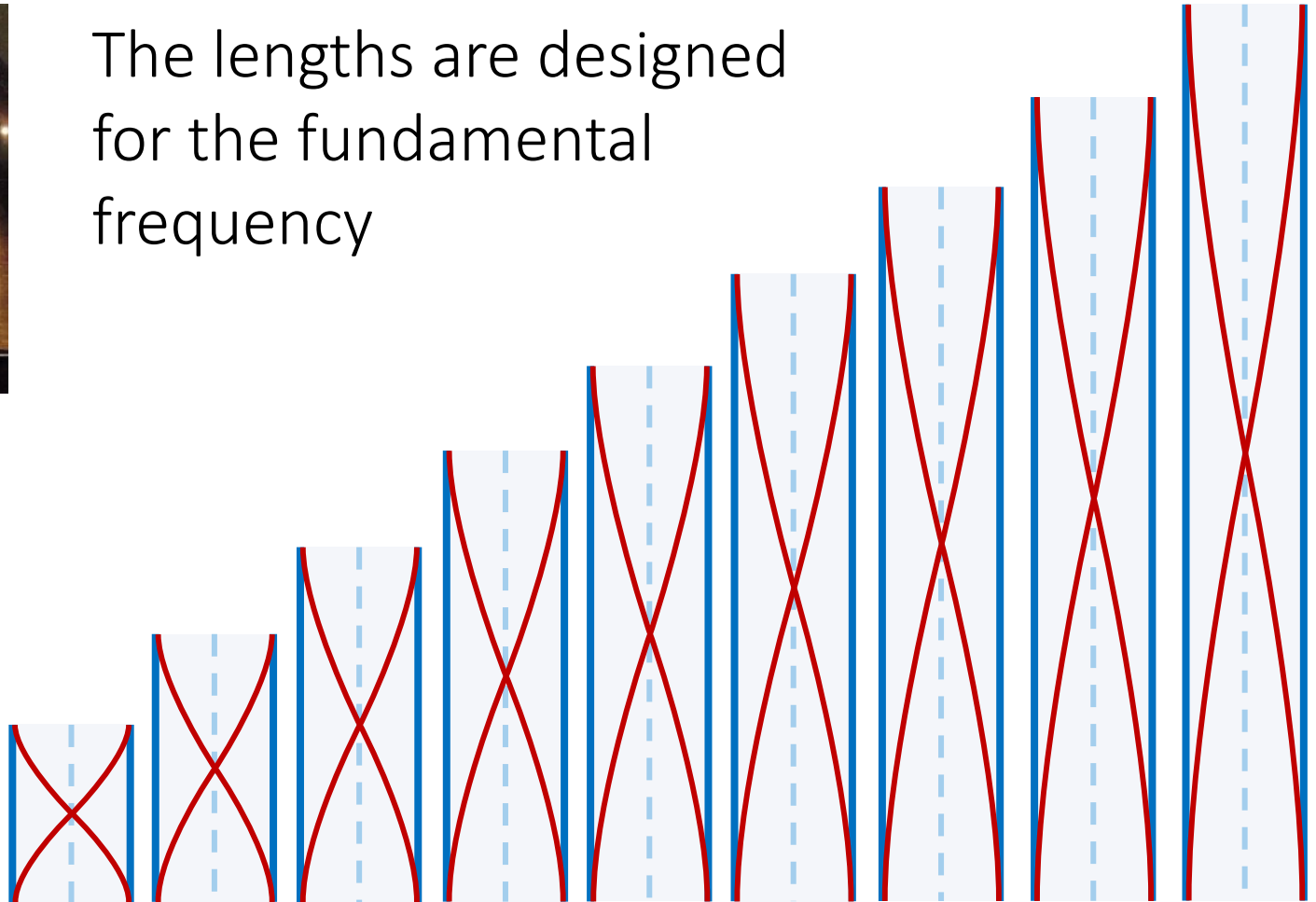
Low pitched sounds have low frequencies



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?

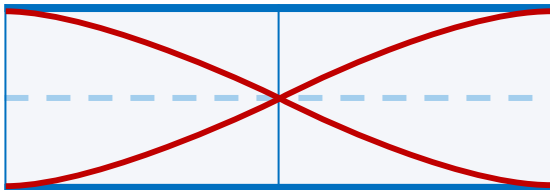
$$v = f\lambda \rightarrow f = \frac{v}{\lambda} = \frac{341}{4.2}$$

$$f = ?$$

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

$$\lambda = 4.2\text{ m}$$

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

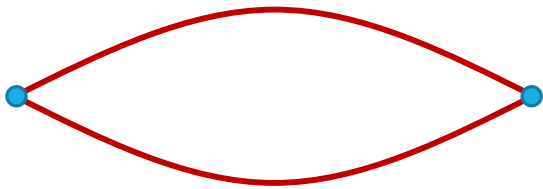


$$L = \frac{1}{2}\lambda \rightarrow \lambda = 2L = 2(2.1) = 4.2\text{ m}$$

Resonant String Practice



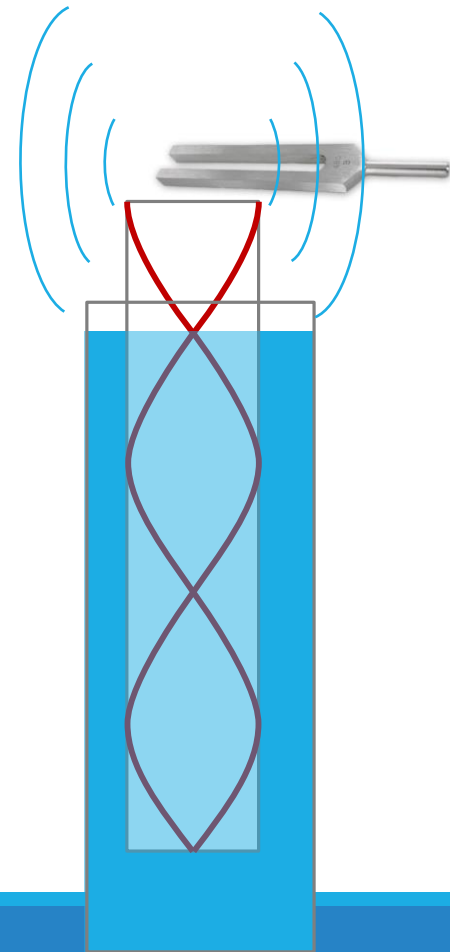
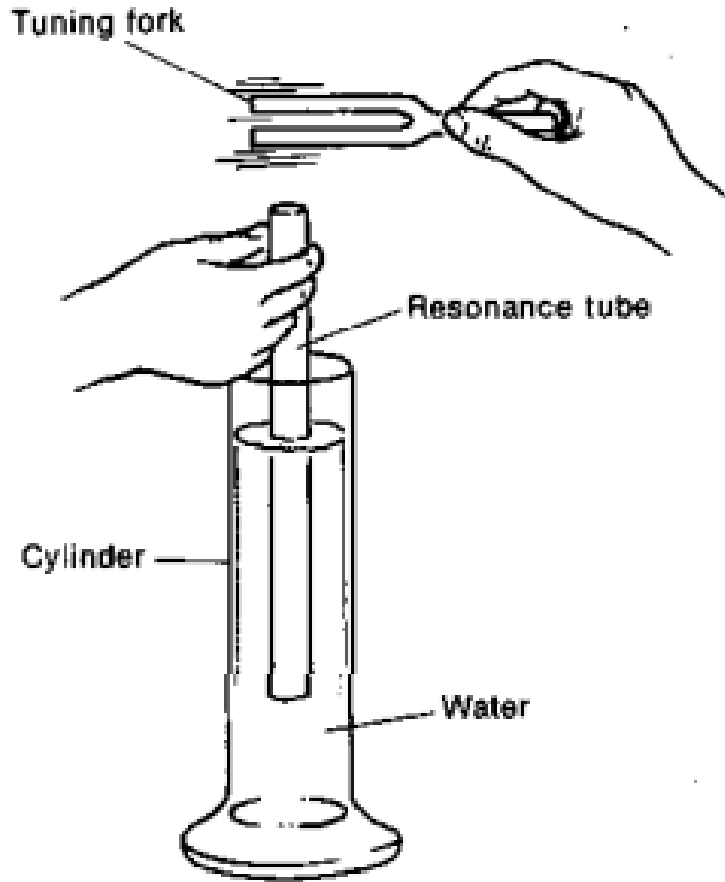
The note produced on a violin string of length **40 cm** produces a wave speed of 250 m/s. What is the first harmonic of this note?



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

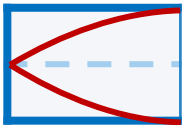
$$\begin{aligned} v &= f\lambda \rightarrow f = \frac{v}{\lambda} = \frac{250}{0.8} \\ f &= ? \\ v &= 250 \text{ m s}^{-1} \\ \lambda &= 0.8 \text{ m} \\ &= \mathbf{312.5 \text{ Hz}} \end{aligned}$$

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?



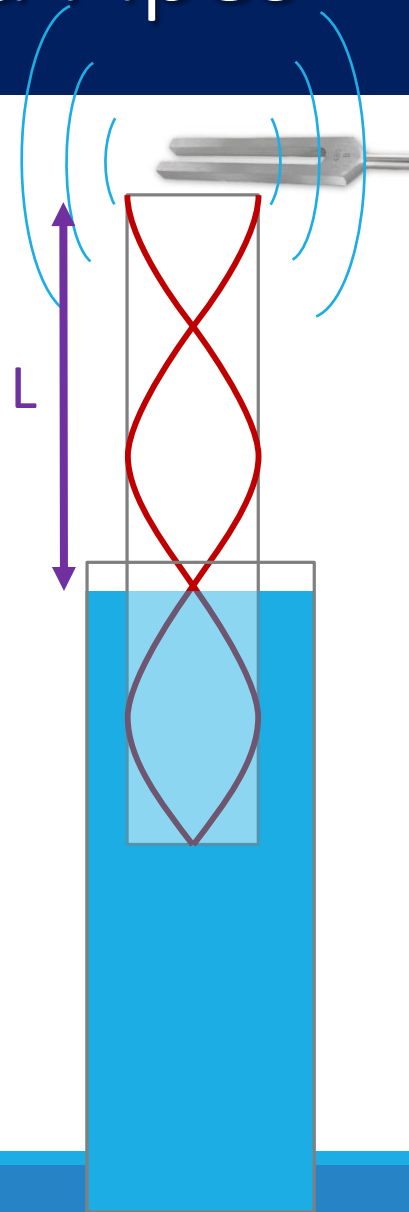
$$L = \frac{1}{4}\lambda \rightarrow \lambda = 4L = 4(0.12) = 0.48 \text{ m}$$

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

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



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



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