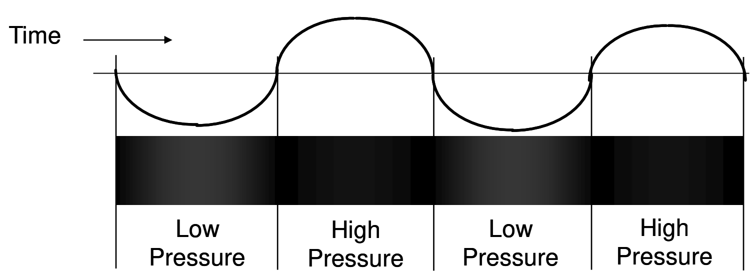
Sound Waves

The Physics of Music

1

Sources of Sound

- Any vibrating object can produce a sound
- The vibrations move molecules in the air creating pressure differences creating sound.



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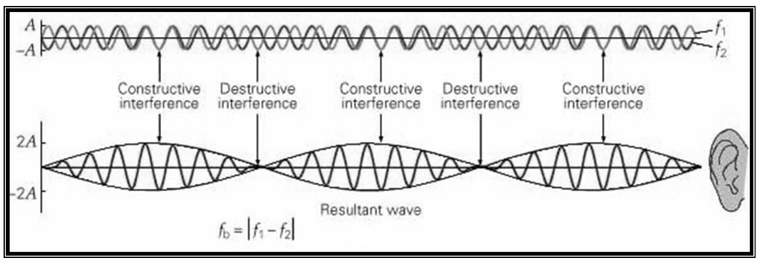
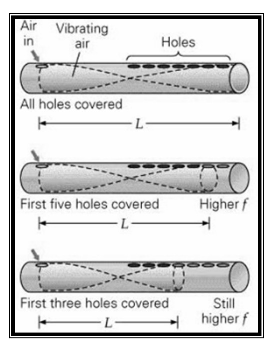
Beats

- Pulsing variation of loudness
- The number of beats per second = the difference between source frequencies
- Humans can detect beat frequencies up to approximately 7Hz
- Over 7Hz we hear a complex wave



Resonance

- How it works
  – Certain frequencies will produce standing waves in a given length of pipe or string
  – These standing waves produce the sound we hear in musical instruments.
  – By changing the length of the string or pipe, we can change the frequency that resonates



Resonance

- Fundamental Frequency
  - the lowest frequency of vibration of a standing wave
- Harmonics
  - whole number multiples of the fundamental frequency

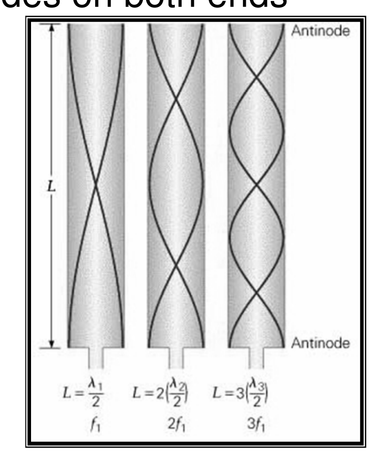
Note on musical vocabulary:
- The fundamental is also the first harmonic

5

Open-pipe resonator

- Resonating tube open at both ends
- Produces a standing wave with antinodes on both ends
- Minimum length is 1/2 λ
  or λ = 2L

Notice <u>all</u> harmonics resonate in a open tube

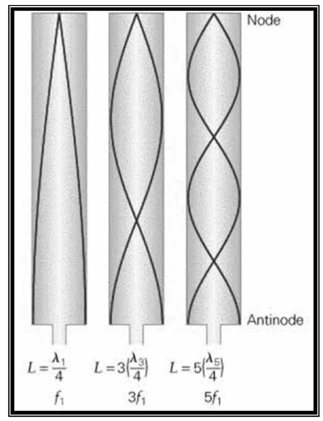


6

Closed pipe resonator

- Resonating tube with one end closed
- Produces a standing wave with a node on one end and an antinode on the other
- Minimum length is 1/4 λ or $\lambda = 4L$

Notice only <u>odd</u> harmonics resonate in a closed tube



Harmonics Sample Problem

- A tuning fork produces resonance when held above a 2.45 m long pipe that is open at <u>both ends.</u> Assuming the speed of sound is 345 m/s, what is the frequency of the tuning fork? What are the next two frequencies that would resonate in the same tube?

Open => $\lambda = 2L$ => All Harmonics

$\lambda = 2(2.45) = 4.9\,m$

$v = \lambda f$

$345 = 4.9(f)$

$f_1 = 70.4\ Hz$

$f_2 = 70.4 \times 2 = 140.8\ Hz$

$f_3 = 70.4 \times 3 = 211.2\ Hz$

Harmonics Sample Problem

- A 392 Hz tuning fork is used with a closed pipe resonator. The length is 0.32 m when the loudest sound is produced. What is the speed of sound? What is the temperature of the air during the experiment?

Open ⇒ $\lambda = 4L$

$\lambda = 4(.32) = 1.28\ m$

$v = \lambda f$

$= 1.28(392)$

$= 501.76\ m/s$

$v = 331 + .6T_c$

$501.76 = 331 + .6T_c$

$170.76 = .6T_c$

$284°C = T_c$