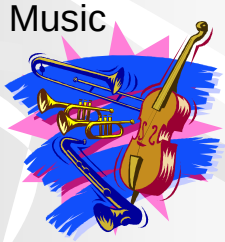
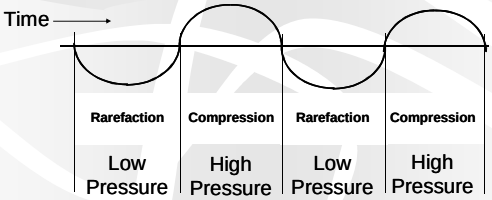
Sound Waves

The Physics of Music



Sources of Sound

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

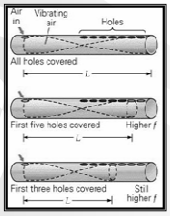


Forced Vibrations and Resonance

- Forced Vibrations
  - The forced transfer of a vibration to other media (Ex: guitar)
- Resonance
  - Occurs when the forced vibration matches the natural frequency of an object
- Resonance can produce a standing wave, creating a louder noise or other results…

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
  - Resonant frequency can also depend on the diameter of the pipe



Resonance

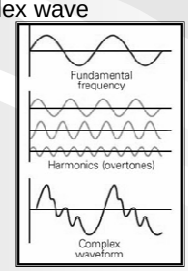
- Fundamental
  - the lowest frequency making up a sound
- Harmonics
  - whole number multiples of the fundamental frequency
- Overtones
  - The first occurrence of resonance above the fundamental frequency

Note on musical vocabulary:

- The fundamental is also the first harmonic
- The first overtone is the second harmonic

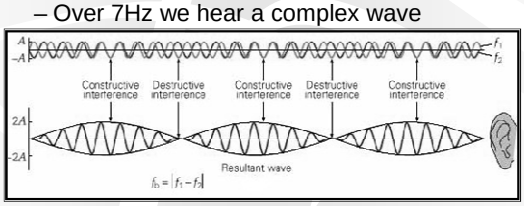
Sound Quality

- Timbre or Quality
  - instrument dependent
  - combined frequencies / complex wave forms



Sound Quality

- Beat
  - pulsing variation of loudness
  - Humans can detect beat frequencies up to approximately 7Hz
  - Over 7Hz we hear a complex wave



Sound Quality

- Dissonance
  - when two notes are played resulting in a unpleasant sound
- Consonance
  - when two notes are played resulting in a pleasant sound or chord

Resonance

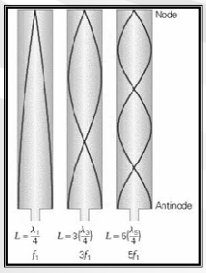
- Closed pipe resonator
  - resonating tube with one end closed
  - produces a standing wave
  - Minimum length is approx. 1/4 λ

$$\lambda = 4L$$

$$f_n = n\left(\frac{v}{4L}\right) \qquad (n = 1,3,5)$$

$$f_n = nf_1$$

Notice only odd harmonics resonate in a closed tube



Resonance

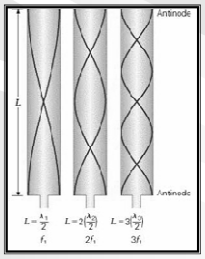
- Open-pipe resonator
  - open at both ends
  - produces a standing wave
  - Minimum length is 1/2 λ

$$\lambda = 2L$$

$$f_n = n\left(\frac{v}{2L}\right) \qquad (n = 1,2,3...)$$

$$f_n = nf_1$$

Notice all harmonics resonate in a open tube



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