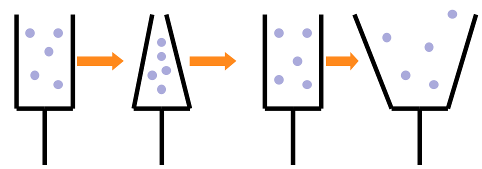
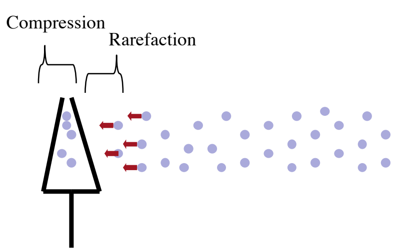
Acoustics, an intro

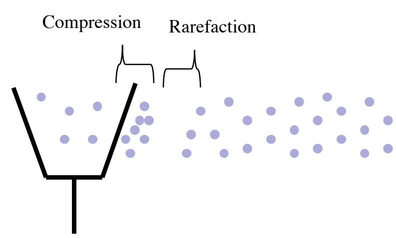
A tuning fork



Tuning fork & air

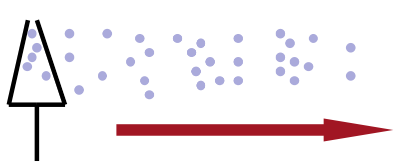


Tuning fork & air



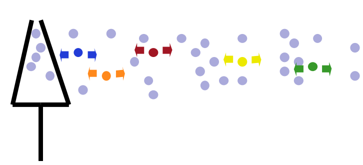
Tuning fork & air

- In this manner, the compression/rarefaction of the air travels across the distance.

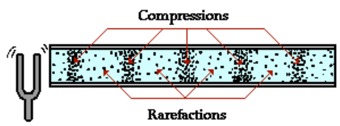


Tuning fork & air

- But no single air molecule moves very far.



Tuning fork



Images from: The Physics Classroom

A guitar string

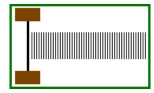
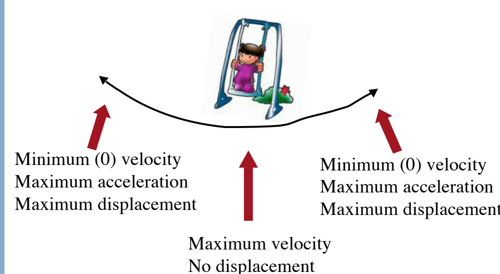


Image source: The Physics Classroom

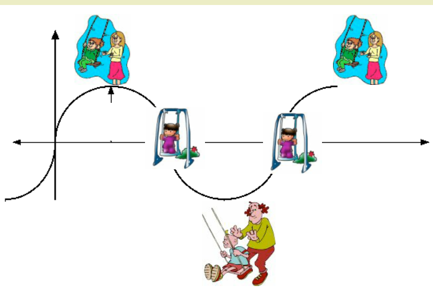
Sinusoids

- **Joseph Fourier's theorem**: any vibration can be resolved into a sum of sinusoidal ones.
- Thus, sinusoids (sine waves) are the building blocks of sound.

Simple harmonic motion



Graphing simple harmonic motion



Graphing sounds & harmonic motion

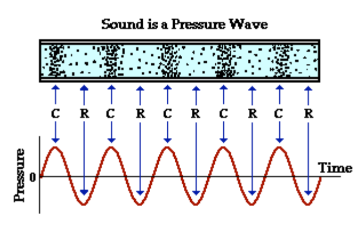
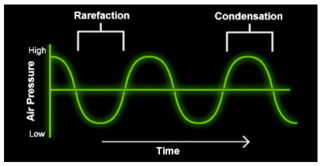


Image source: The Physics Classroom

Sine waves

- Regular, symmetric, continuous back & forth displacements of a vibrating object



- Because the wave keeps repeating itself, we only need diagram one complete transition (a cycle)

Image source: The Soundry, ThinkQuest

Frequency

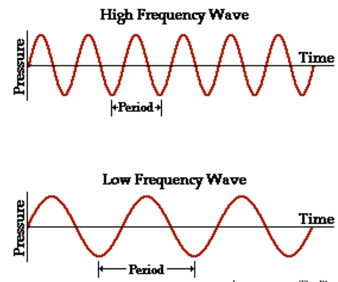


Image source: The Physics Classroom

Frequency - related concepts

- Period
- Wavelength

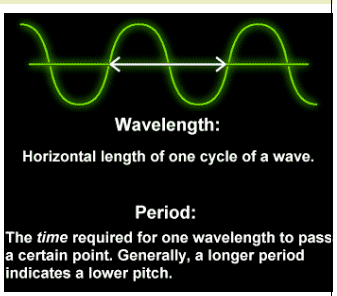
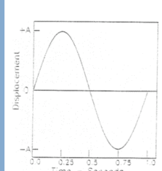


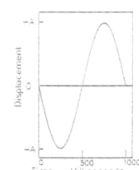
Image source: The Soundry, ThinkQuest

Starting phase

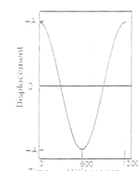
- degrees of angle at start of waveform



0 degrees starting phase



180 degrees starting phase



90 degrees starting phase

Images from Yost, *Fundamentals of Hearing: An Introduction*

Amplitude

- Amount of vibratory displacement

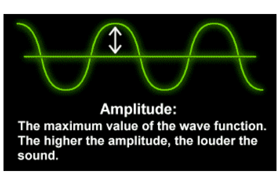


Image source: The Soundry, ThinkQuest

Amplitude

- instantaneous amplitude
- peak-amplitude
- peak-to-peak amplitude
- RMS (root mean square) amplitude
  - For sinusoids, RMS ≈ 0.707 of peak amplitude & RMS ≈ 0.3536 peak-to-peak amplitude

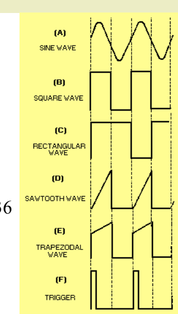


Image from http://www.tpub.com/neets/book9/36.htm

Summary - waves

- http://id.mind.net/~zona/mstm/physics/waves/introduction/introductionWaves.html

Interference, reflection & damping

Sounds in the real world….

Reverberation vs. echo

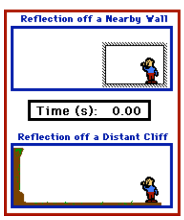
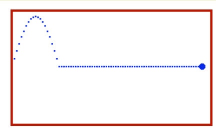


Image source: The Physics Classroom

Standing waves



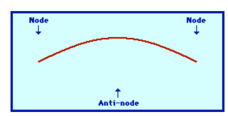
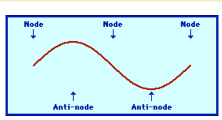


Image source: The Physics Classroom

Standing waves, cont.



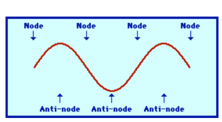


Image source: The Physics Classroom

More standing waves

- On a violin (both ends fixed): http://id.mind.net/~zona/mstm/physics/waves/standingWaves/standingWaves1/StandingWaves1.html

Standing waves, cont.

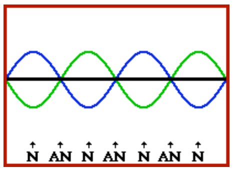


Image source: The Physics Classroom

Singing in the shower

- When you sing in the shower, some frequencies seem to make the whole room resonate.
  - This is because those frequencies cause standing waves - the frequency is reflected back on itself as it bounces between the walls, interfering constructively.
  - The first standing wave's frequency is c/2L, where c=speed of sound, L= distance between the walls.

Listening in a room

- The same thing happens in all rooms.
- Note that the first resonance and odd multiples are near zero in the center of the room.
- You end up with more bass sounds near a wall, and a different frequency response throughout the room
- With smaller rooms, you get more coloration (the modes are distributed less evenly)

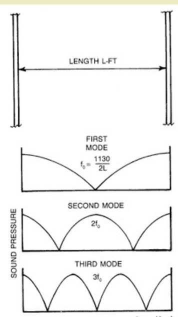


Image from http://www.audioholics.com/education/acoustics-principles/listening-room-acoustics-1