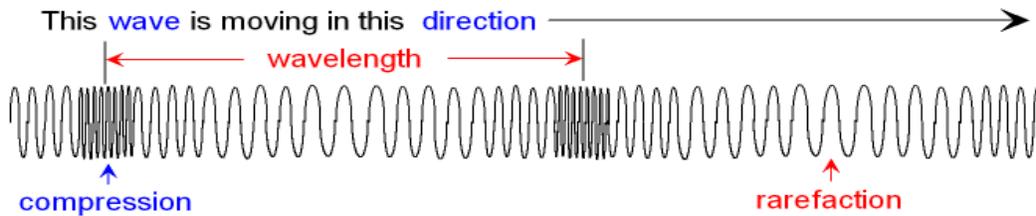


Sound Waves

“It is not the noise of the shout of victory, Nor the noise of the cry of defeat,
But the sound of singing I hear.” Exodus 32:18

- sound: vibrations traveling through a medium in the form of longitudinal pressure waves; can also be transmitted through liquids and solids
- In a sound wave, particles of the transmitting medium (such as air) oscillate back and forth parallel to the direction of wave movement

Complete sound wave: compression pulse + rarefaction pulse:

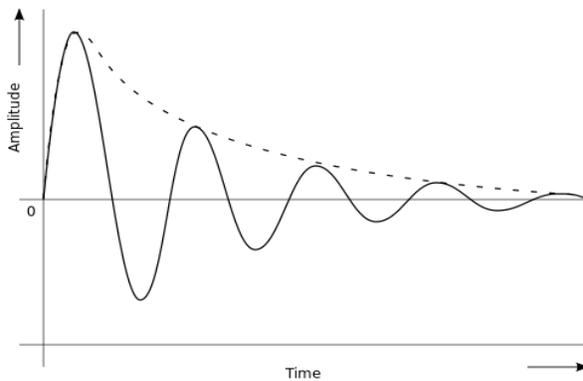


High pressure/air molecules bunched low pressure/air molecules further apart

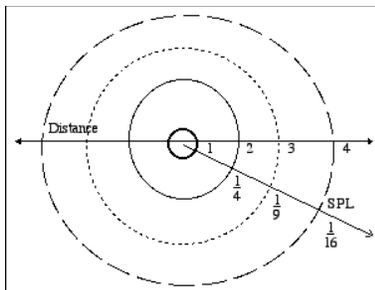
- Unless stopped by friction, (string) will vibrate until all energy has been transferred to the air as sound waves
- Intensity: strength of a sound wave; equals power hitting a surface with an area of one unit

SI unit for intensity = W/m^2

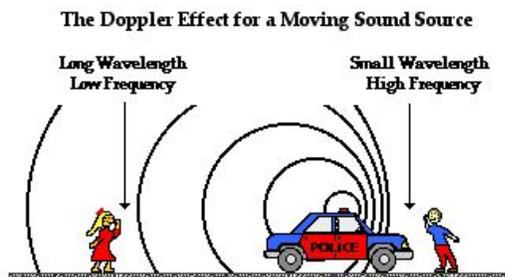
Intensity of sound will change depending on the amplitude



- Intensity of sound is inversely proportional to square of the distance between source of sound and recipient of sound



- Loudness: effect of intensity on the way the human ear perceives sound; subjective because it describes how sound is perceived
Unit of sound intensity = bel (B) → an increase of 1B represents a 10-fold increase in intensity (8B sound is 10x as intense as 7B); decibel (1/10 B) unit more commonly used
[chart p. 261]
- Pitch: effect of frequency on the way the human ear perceives sound; determined by frequency [chart p.262]
- Audible sound: sound that can be heard; humans' audible range = 20Hz-20,000Hz
Infrasonic: sounds below 20Hz
Ultrasonic: sounds above 20,000Hz
- Doppler effect: change in sound frequency caused by an object's motion; depends on relative motion (sound of ambulance siren)



- Sound waves travel much more slowly than light; all sound waves travel at the same speed through a particular medium regardless of wavelength, frequency, or intensity
- Main factor affecting speed of sound in air is the temperature of the air
At 0°C the speed of sound is 331 m/s but must take into account any added temp:

$$\text{Speed of sound} = 331 \text{ m/s} + [0.61 \text{ m/s} \times \text{Celsius temperature}]$$

*do the multiplication step first before adding the 331 m/s!

- Sound travels at different speeds through different media; sound travels 4x faster through water than air and about 15x faster through steel than air (remember particle movement)
- Supersonic: speeds above the speed of sound
Subsonic: speeds below the speed of sound
- Shock wave: violent compression pulse as a result of constructive interference between waves when airplane exceeds the speed of sound and "outruns" its own sound waves; sonic boom heard

Behavior of Sound Waves

- Sound waves obey the law of reflection
- Reverberation: multiple reflections

- Echo: sound heard distinctly after being reflected from some object
Interval between hearing original sound and echo must be $>0.1\text{s}$ or $>17\text{m}$
- SONAR: sound navigation and ranging
Reflection used to measure distance between objects
- Absorption: dissipating the energy of sound waves in matter
- Refraction: sound waves bend toward the medium that slows them down (sound travels more slowly in cool air than warm air)
- Diffraction applies to sound waves (spread out)