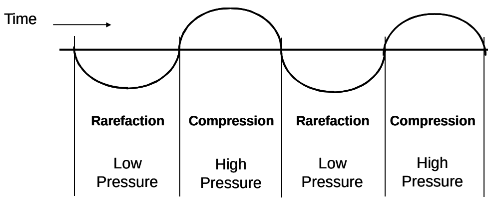
SOUND WAVES

Sound

- A source, like a speaker, compresses air molecules at regular intervals, creating differences in pressure over time.
- This creates a longitudinal wave



Speed of Sound

- The speed of a sound wave depends on the medium. (Table 14-1, p472)
- Speed of sound in air = 331 m/s @ 0^{o} C
- Speed increases 0.6 m/s for each 1^{o}C increases in temperature
- Velocity at any temperature can be found using: $v = 331 + 0.6T_c$
- Follows all properties of waves including:

$$v = \lambda f$$

- Wavelength, not frequency, changes when a wave changes speed

Intensity

- Rate at which the energy of the sound wave strikes a unit area

$$I = \frac{P}{4\pi R^2}$$

Where P is the power in watts and $4\pi R^2$ is the area in square meters.

Intensity Level or Loudness

- Depends on the amplitude of the wave
- Measured in decibels (dB)
- 0 dB is the lowest level sound that people can hear 0 dB = 1×10^{-12} W/m^2. (I_o)
- Loudness is the relative intensity to this level.

$$\beta = 10 \log \frac{I}{I_o}$$

Decibel Level, Intensity, and Loudness

- Logarithmic relationship
- 10 Decibel increase - increases the intensity by 10 times, and the sound is approximately twice as loud
- 20 Decibel increase - increases the intensity by 100 times, and the sound is approximately 4 times as loud
- 30 Decibel increase - increases the intensity by 1000 times, and the sound is approximately 8 times as loud

Pitch

- How high or low the perceived sound is
- Frequency of sound
  - High frequency
  - Low frequency

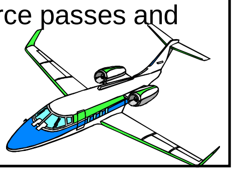
Pitch - Octaves

- Pythagoras determined musical scales based on the length of string when plucked.
- Octaves
  - difference in pitch when the two notes' frequencies have a ratio of 2:1

220 Hz ← Octave → 440 Hz ← Octave → 880 Hz

Doppler Shift

- Effect observed when a sound source moves toward you.
- Occurs with all wave motion
- Frequency gradually increases as the source approaches, then suddenly drops to a lower pitch as the source passes and moves away.



Doppler Shift

- Determining the Doppler Effect Frequency

Source moving towards observer

$$f' = f_o \frac{v}{v - v_s}$$

Source moving away from observer

$$f' = f_o \frac{v}{v + v_s}$$

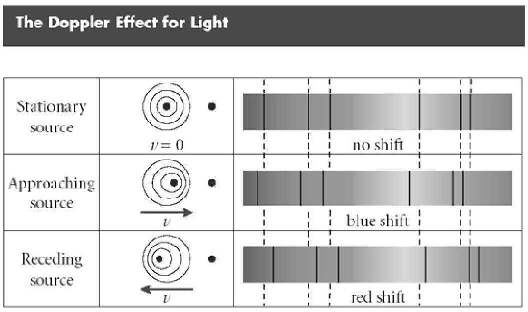
Observer moving towards source

$$f' = f_o \frac{v + v_t}{v}$$

Observer moving away source

$$f' = f_o \frac{v - v_t}{v}$$

Doppler Effect and Light

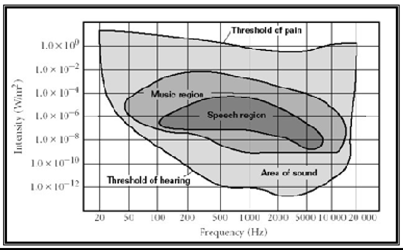


Pitch – the sound spectrum

- Humans can hear frequencies between 20 Hz and 20,000 Hz. These are called the audible sound waves.
- Sounds below 20 Hz are called infrasonic.
- Sounds above 20,000 Hz are called ultrasonic.
  - Used for medical imaging and echolocation

Audible Range

- Whether we can hear a sound or not depends on the frequency and intensity of the sound.



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