

LOUDNESS AND LOCALIZATION

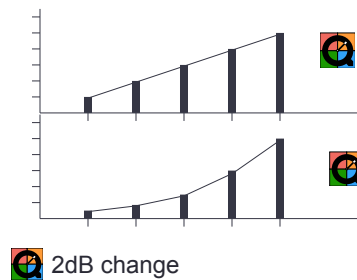
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Perception Basics: Loudness

- Strongly related to amplitude
- Approximately logarithmic
- Double loudness: 10-fold increase in intensity
- Sensitive to about 1dB
- Fletcher-Munson curve: frequency dependent sensitivity

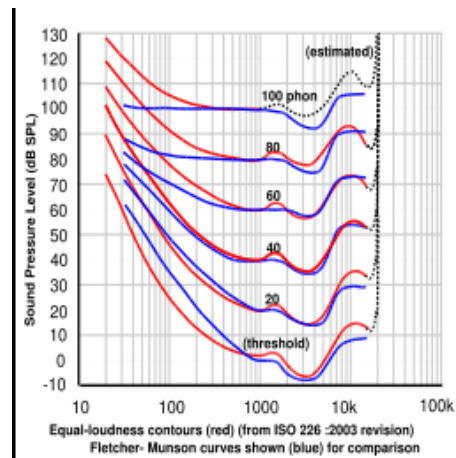


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Fletcher-Munson Curve



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Perception: Localization

- Multiple cues
 - Relative amplitude
 - Relative phase
 - Spectral effects of pinnae (outer ears)
- Taken together, these effects are sometimes Head-Related Transfer Function
- Environmental cues are also important:
 - Reflection of sound
 - Reverberation and ratio of reverberation to direct sound
 - Knowledge of sound source (through vision, recognition, ...)



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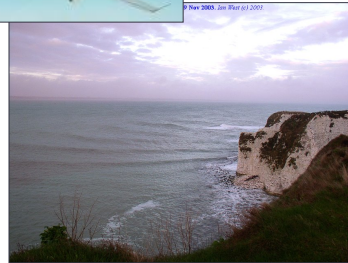
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More Acoustics

- Speed of sound: about 1 ft/ms
- Sound reflects from surfaces
 - >20ms: echo
 - Many fine reflections: reverberation
- Sound also refracts
Wavelengths vary from 50 feet to fraction of an inch
- Linearity: (for pressure signals x and y):
 - $F(ax) = aF(x)$
 - $F(x + y) = F(x) + F(y)$



737: 575 mph (mach 0.82)
Sound: 701 mph
At sea level: 770 mph



Why does Linearity matter?

- Air, rooms, performance spaces are very linear
- What you hear is weighted sum of sound sources
- Filters weight or delay frequencies differently but independently
- Superposition principle



Summary

Perception	Phenomenon
Pitch	Frequency (20-20 KHz)
Loudness	Intensity (90 dB)
Timbre	Spectrum (and other)

- Perception is roughly logarithmic
- Struck objects typically exhibit characteristic frequencies with exponential decay rates
- Driven oscillators typically exhibit periodic signals, hence harmonic spectra
- Superposition principle applies to sounds