









The Physic	cs of Sound	
-	Speed of Sound	
Air (at sea level, 20 C)	343 m/s (1235 km/h)	V=(331+0.6T) m/s
Water (at 20 C)	1482 m/s (5335 km/h)	
Steel	5960 m/s (21460 km/h)	
Tendon	1650 m/s	
Wood hard vs soft	4267 m/s vs 3353 m/s	
Speed of Sound		
 Proportional to 	sgrt(elastic modulus	s/density)
• Second order d sound => nonli	ependency on the an near propagation effe	nplitude of the ects
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dB (SPL)	Source (with distance)	
194	Theoretical limit for a sound wave at 1 atmosphere environmental pressure; pressure waves with a greater intensity behave as <u>shock waves</u> .	
188	Space Shuttle liftoff as heard from launch tower (less than 100 feet) (source: acoustical studies [1] [2]).	
180	Krakatoa volcano explosion at 1 mile (1.6 km) in air [3]	
160	<u>I Garand</u> being fired at 1 meter (3 ft); <u>Space Shuttle</u> liftoff as heard from launch pad perimeter pprox. 1500 feet) (source: acoustical studies [4] [5]).	
150	Jet engine at 30 m (100 ft)	
140	Low Calibre <u>Rifle</u> being fired at 1m (3 ft); the engine of a <u>Formula One car</u> at 1 meter (3 ft)	
130	Threshold of pain; civil defense siren at 100 ft (30 m)	
120	<u>Space Shuttle</u> from three mile mark, closest one can view launch. (Source: acoustical studies) [6] [7]. [Train horn]] at 1 m (3 ft). Many foghorns produce around this volume.	
110	<u>Football</u> stadium during <u>kickoff</u> at 50 yard line; <u>chainsaw</u> at 1 m (3 ft)	
100	Jackhammer at 2 m (7 ft); inside discothèque	
90	Loud factory, heavy truck at 1 m (3 ft), kitchen blender	
8o	Vacuum cleaner at 1 m (3 ft), curbside of busy street, PLVI of city	
70	Busy <u>traffic</u> at 5 m (16 ft)	
60	Office or restaurant inside	
50	Quiet restaurant inside	
40	Residential area at night	
30	Theatre, no talking	
20	Whispering	
10	Human breathing at 3 m (10 ft)	
0	Threshold of human hearing (with healthy ears); sound of a mosquito flying 3 m (10 ft) away	





Developeouctice		
sychoacoustics	Physical Quantity	Perceptual Quality
 Psychoacoustics: a branch of science dealing with hearing, the 		
sensations produced by sounds.	Intensity	Loudness
Perceptual attributes of a sound		
vs measurable physical quantities:	Fundamental Frequency	Pitch
 Many physical quantities are perceived on a logarithmic scale (e.g. loudness). 	Spectral Shape	Timbre
• Perception is often a nonlinear		
physical quantity being measured (e.g. equal loudness).	Onset/Offset Time	Timing
 Timbre can be used to describe why musical instruments sound different 	Dhago Difference	Location
What factors contribute to speaker	(Binaural Hearing)	Location































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References

- Some of the slides in these lectures are adapted from the presentation: "Can Advances in Speech Recognition make Spoken Language as Convenient and as Accessible as Online Text?", an excellent presentation by: Dr. Patti Price, Speech Technology Consulting Menlo Park, California 94025, and Dr. Joseph Picone Institute for Signal and Information Processing Dept. of Elect. and Comp. Eng. Mississippi State University
- Several anatomic graphics are from Wikipedia
- Fundamentals of Speech Recognition by Lawrence Rabiner, and Biing-Hwang Juang (Hardcover, 507 pages; Publisher: Pearson Education POD; ISBN: 0130151572; 1st edition, April 12, 1993)
- NIH: https://training.seer.cancer.gov/anatomy/respiratory/passages/larynx.html

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