



Infocommunication Sound, hearing and speech



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Structure of the human ear



Source: http://www.tutorvista.com/content/science/science-i/sound/structure-ear.php

Békésy György / Georg von Békésy Nobel prize in 1961 (function of the cochlea)



Source: http://braintour.harvard.edu/archives/portfolio-items/von-bekesy-experiments-hearing

Sound pressure level

Source: http://personal.cityu.edu.hk/ ~bsapplec/sound.htm



Sound pressure level

- 440 Hz tone (A4 on musical scale)
 - reduced in 1 dB steps
 - reduced in 3 dB steps
 - reduced in 5 dB steps



Limits of human hearing



Source: https://people.ece.cornell.edu/land/courses/ece5030/FinalProjects/

Fletcher & Munson 1933 experiment



Source: http://www.effectrode.com/wp-content/uploads/fletcher_munson_chart.jpg

Equal loudness contours



Loudness

- various frequencies at a constant SPL (the perceived loudness of tones varies at equal sound intensity)
- which tone sounds twice as loud as the reference tone?
 - reference tone + same tone 5 dB higher
 - reference tone + same tone 8 dB higher
 - reference tone + same tone 10 dB higher





Loudness war

Source: https://en.wikipedia.org/ wiki/Loudness_war

Loudness war Metallica: Death Magnetic

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Source: https://en.wikipedia.org/ wiki/Loudness_war

Loudness war



Source: https://www.youtube.com/watch?v=3Gmex_4hreQ

Some of the albums that have been criticized for their sound quality include the following:

Artist 🗢	Album 🗢				
Arctic Monkeys	Whatever People Say I Am, That's What I'm Not ^[6]				
Black Sabbath	13[57]				
Bob Dylan	Modern Times ^[40]				
	Together Through Life ^[40]				
Christina Aguilera	Back to Basics ^[3]				
The Cure	4:13 Dream ^[58]				
Depeche Mode	Playing the Angel ^[59]				
The Flaming Lips	At War with the Mystics ^{[6][note 3]}				
Led Zeppelin	Mothership ^[60]				
Lily Allen	Alright, Still ^[61]				
Los Lonely Boys	Sacred ^[3]				
Nine Inch Nails	Pretty Hate Machine (2010 Remaster) ^[62]				
Metallica	Death Magnetic ^{[63][note 4]}				
Miranda Lambert	Revolution ^[64]				
Oasis	(What's the Story) Morning Glory? ^[6]				
Paul McCartney	Memory Almost Full ^[65]				
Paul Simon	Surprise ^[66]				
Pearl Jam	Ten (2009 remaster) ^{[67][68][69]}				
Queens of the Stone Age	Songs for the Dear ^[6]				
Red Hot Chili Peppers	Californication ^{[3][6]}				
Ghost	Infestissumam ^[70]				
Rush	Vapor Trails ^[71]				
The Stooges	Raw Power (1997 remaster)[66]				

Loudness war

Source: https://en.wikipedia.org/ wiki/Loudness_war



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Spatial hearing "hearing throne"



Time domain masking - Forward



- masking tone + tone that is semitone down
 - with a 100 ms delay in between
 - with a 10 ms delay in between



Time domain masking - Backward



- initial tone is going to be masked by the tone that follows
 - delay: 100 ms
 - delay: above 10 ms
 - delay: below 10 ms



Frequency domain masking

- Pure tones mask higher frequencies better than lower frequencies
 - Mask high freqs
 - Mask low freqs

