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2011-06521

Machine Exercise 3: Threshold

Adjust the volume on your computer for proper playback of the tones. Write down the number of levels you can hear in the 3500 Hz sequence.
After adjusting the volume, I heard 18 levels from the 3.5kHz sequence.

Listen to the tone. If you can hear the tone, reduce the sound intensity by 3 dB.
Given we want to reduce the sound by 3dB,

$$L_1 - L_2 = -3dB$$
$$10log(I_1/I_{ref}) - 10log(I_2/I_{ref}) = -3$$
$$log(I_1/I_{ref}) - log(I_2/I_{ref}) = -0.3$$

Given that $log(b) - log(a) = log(b/a)$ and $log_b(n) = a \leftrightarrow b^a = n$,

$$log((I_1/I_{ref})/(I_2/I_{ref})) = -0.3$$
$$log(I_1/I_2) = -0.3$$
$$I_1/I_2 = 10^{-0.3}$$
$$I_1/I_2 = 0.5012 \approx 0.5$$

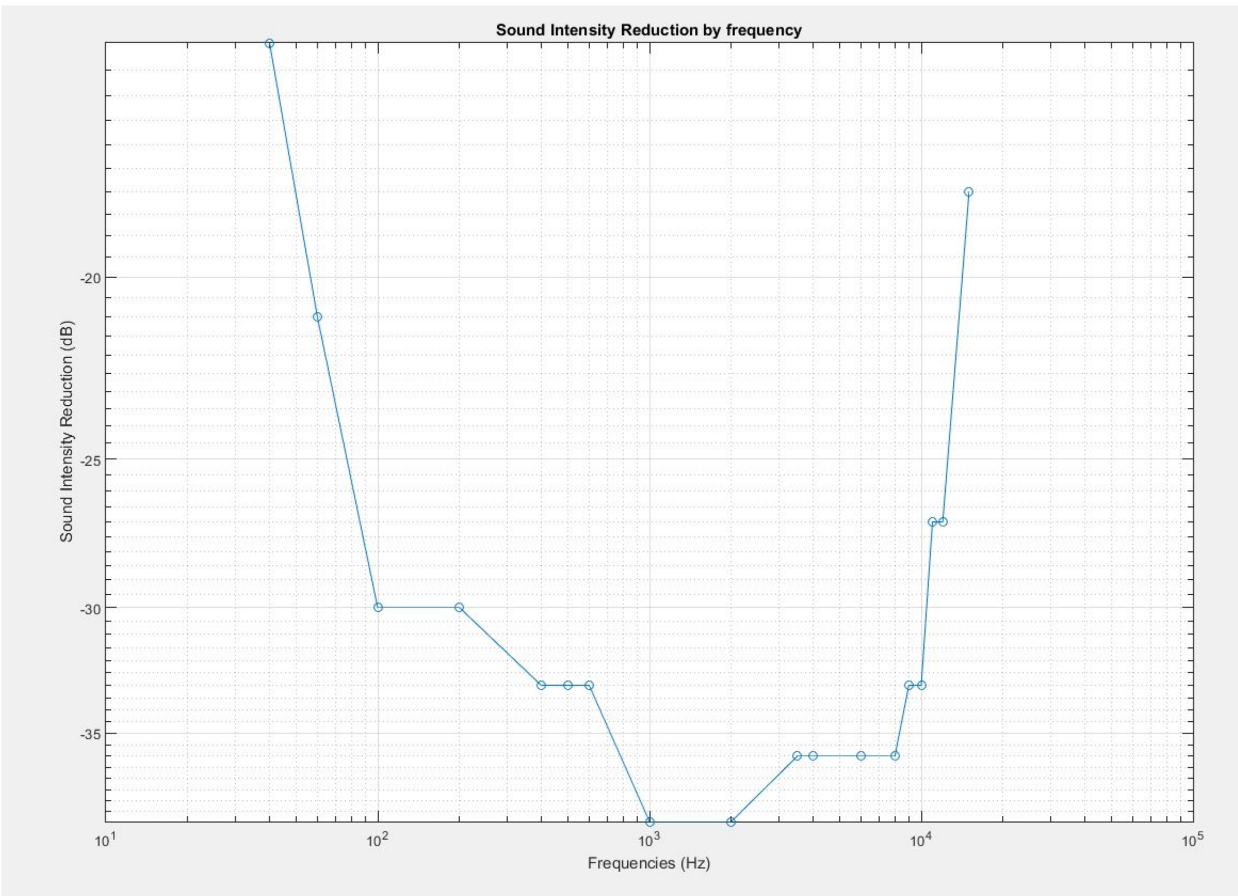
Therefore to reduce the sound by 3dB, the intensity should be halved.

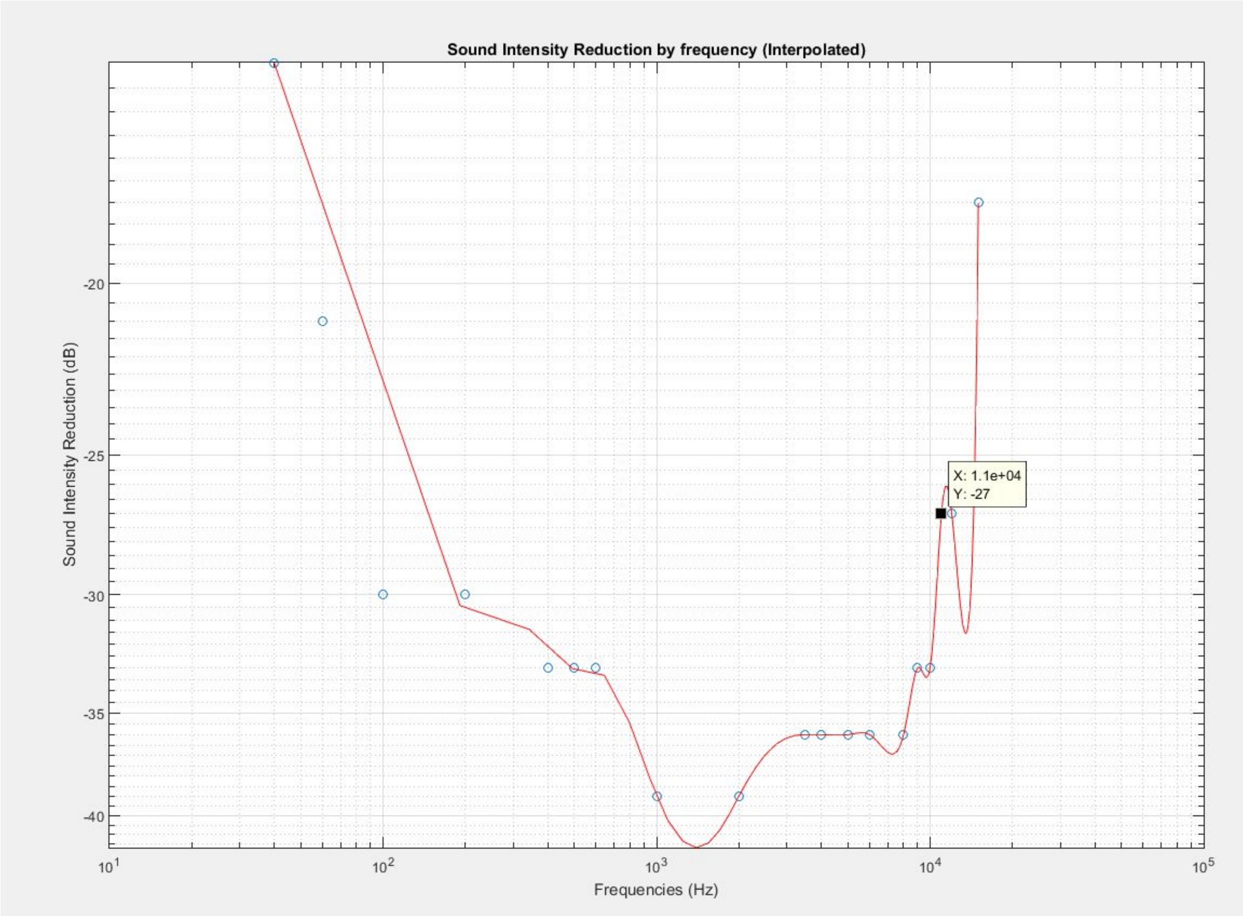
Complete the table below to indicate the sound reduction until a tone is inaudible.

Frequency (Hz)	Sound intensity reduction (dB)	Frequency (Hz)	Sound intensity reduction (dB)
40	15	3500	36
60	21	4000	36
100	30	5000	36
200	30	6000	36
400	33	8000	36
500	33	9000	33
600	33	10000	33
1000	39	11000	27
2000	39	12000	27
		15000	18

Plot your result. Were you able to get a similar plot above?
Shown below is the plot of the sound intensity reduction based on frequency. Also below is an interpolated version of the plot. Even though the plot is not that accurate to the sound threshold plot since frequencies tested are limited and we only reduced the sound in 3dB intervals, we can observe some features of the sound threshold plot.

First, we can hear frequencies at lower intensities as it reaches 1kHz, afterwhich we can see a dip at around 1-2 kHz where the tones are heard at lower intensities. Larger intensities are then needed to hear tones until the 10kHz mark. Afterwhich, we see another dip before intensity reduction decreases again at around the 15kHz mark.





Questions:

A 3 dB decrement corresponds to what fractional decrease in amplitude?

Based on the computation above, a 3dB decrement means a reduction of the amplitude by half.

Using your results, how much "louder" does a tone at 40 Hz have to be compared to a tone at 3500 Hz in order to be perceived as equally loud? Give your answer both in dB, and as a numerical factor.

With 40Hz being heard at a maximum of a 15db reduction, while the 3.5kHz is heard at a maximum of 36dB, the 40Hz tone should be **21dB** or $2^7 = 128$ times *louder* compared to the 3.5kHz tone.

Repeat the experiment using 0.5-second tones. How does it affect your curve?

Frequency (Hz)	Sound intensity reduction (dB)	Frequency (Hz)	Sound intensity reduction (dB)
40	18	3500	30
60	21	4000	33
100	24	5000	33
200	27	6000	33
400	30	8000	36
500	33	9000	33
600	33	10000	33
1000	33	11000	27
2000	36	12000	27
		15000	18

When we used 0.5 second tones, the pattern is still similar to the sound threshold chart given, but we can observe that the 0.5 second tones are less audible at lower decibels compared to the 0.1 second tones.