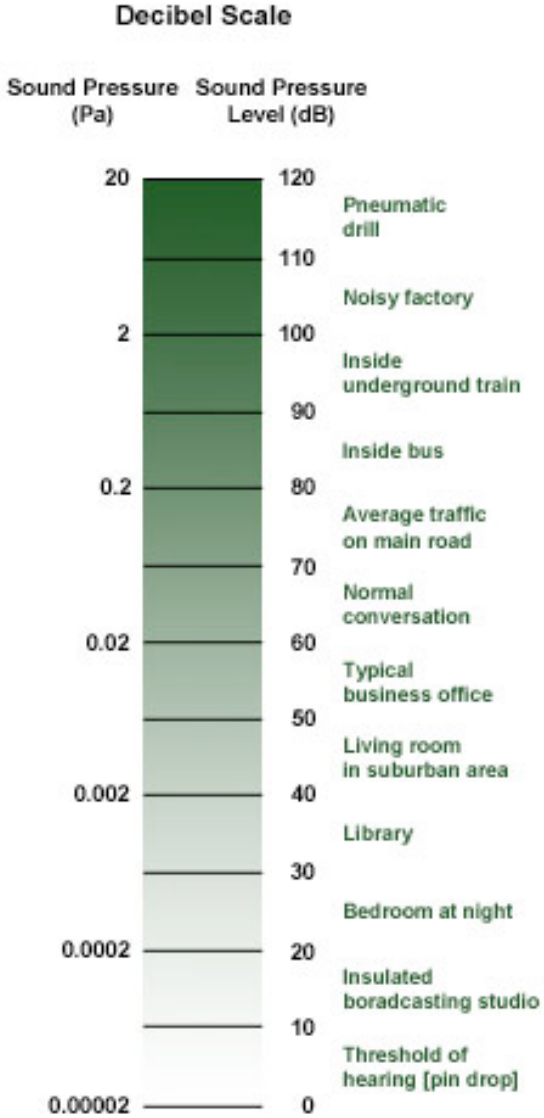
Loudness Isn't Linear

Introduction

You may not have ever really noticed it, but loudness not linear. Ok, technically, that may not be the best way to say it. It is very obvious to us that if you are farther away from the source of a sound, it is not as loud. The closer you get, the louder the sound is. But the relationship between loudness and distance is not a linear one. If you are 5 feet from the stereo speaker, and move to a distance of 10 feet away, the distance is double, but the sound is not half as loud. And if you are 20 feet from the speaker, and move to a distance of 25 feet, the change in distance is still 5 feet—but the difference in sound level is not the same as the change from 5 to 10 feet. By measuring the decibel level of a sound at increasing distance from its source, we will show ourselves exactly what that relationship looks like.

Objectives

- Become familiar with the decibel scale
- Measure loudness as a function of distance from a point source
- Prepare a graph by hand, scaling the axes appropriately and drawing a best-fit curve
- Examine the graphed data and extrapolate from the observed trend
- Measure your maximum audible frequency and observe how it decreases with age



Equipment

- Vernier Sound Level Meter
- Tone generator

Procedure

- This may be the hardest thing we do all semester: **30 minutes of solid silence**. If you get straight to work, you can get all the necessary data collected very quickly. The quieter you are, the faster it goes, and the sooner we can all *stop* being quiet.
- Use the **Sound Level Meter** (**SLM**) to measure the ambient noise level in the room. The meter switches should be toggled to settings **S**, **RESET**, and **A**. To turn the meter on, slide the power switch to the **LO** position. The display shows you the noise level in decibels (dB). When the room is quiet (**no one is talking**), record the dB reading on the meter. Record three values, separated by about 10 or 15 seconds, from several different positions in the room.
- Your instructor will position a sound source at the front of the room. The source will broadcast "pink" noise, which is like white noise, but at a slightly lower (and easier to listen to) frequency. Step right up to the source (you will be about 2 tiles away from the speaker). Hold the **SLM** at about the same height as the speaker and record this dB reading (distance = 1).
- Step back **two tiles** (distance = 2) and record the level again, keeping the **SLM** at the same height. Continue to step back **two tiles**, keeping the distance you step back as even as possible, and keep holding the **SLM** at the same height. Record the sound level (dB) at each step, until you have reached the far end of the room and can't step back any further.
- After everyone has recorded a complete data set, we will do a hearing check. An increasingly high frequency tone will be broadcast, and you should note at what frequency you can no longer hear the sound. Also record the highest audible frequencies of your lab partners.

Data & Analysis

If you have not already, record your data in a neat table.

AMBIENT NOISE (DB)				AMBIENT AVERAGE (DB)	

DISTANCE	SOUND LEVEL (DB)	DISTANCE	SOUND LEVEL (DB)	DISTANCE	SOUND LEVEL (DB)
1		7		13	
2		8		14	
3		9		15	
4		10		16	
5		11		17	
6		12		18	

STUDENT		MAXIMUM AUDIBLE FREQUENCY (HZ)	STUDENT		MAXIMUM AUDIBLE FREQUENCY (HZ)
1			3		
2			4		

1. Calculate the average ambient background noise from the three values you recorded. When no one is speaking, how loud is it in the room?
2. In your lab notebook, make a graph of sound level as a function of distance. This means that **sound level** goes on the **y-axis**, and **distance** is on the **x-axis**. Turn your notebook sideways so the x-axis is on the long edge of the page. Leave plenty of room on the distance axis to extrapolate. You do not have to scale the y-axis from zero; start the sound axis at whatever minimum value is appropriate for the data. If the **ambient noise level** in the room is (for example) 43 dB, scale your y-axis from 40 dB.
3. Is your graph linear? Draw a smooth curve to fit your data, but do not "connect the dots."
4. Is there a bigger change in sound level when you are closer to the source (i.e., moving from 1 to 2 or 2 to 3) or farther from the source (moving from 15 to 16 or 16 to 17)? So, at a concert what makes a bigger difference: seats in the 3rd row compared to the 10th row, or seats in the 30th row compared to the 37th row?
5. How far from the source do you have to get before the sound level approximately matches the background noise? Use your graph to extrapolate the curve and make an estimate.
6. It's a cliché that old people get deaf. But it's a cliché for a reason; there is a natural hearing loss which occurs as we age. We lose the ability to hear very high frequencies, and the loss begins in our twenties. Is there much of a difference in the maximum audible frequencies between you and your lab partners? (Is there much of an age difference, either?) Compare these values to the maximum frequency reported to you by your (much older, and consequently much deafer) instructor.
7. So if you owned a convenience store, and wanted to keep kids from loitering around the premises, what kind of deterrent could you design which would repel the adolescents, but which the adults would never notice? (Note: I a not making this up: http://en.wikipedia.org/wiki/The_Mosquito) Can you think of any other applications or ways to use sound frequencies which are inaudible to human ears?