UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Electrical and Computer Engineering,
Department of Speech and Hearing Sciences, and
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ECE 598 The Speech Chain

Laboratory Exercises 1

Fall 2006

Labs for the week of: Monday, September 11, 2006
Write-up due in lab during the week of: Monday, September 18, 2006

Problem 1.1

The purpose of this exercise is to get used to an SPL meter.

(a) What is the difference between "fast response" and "slow response" on the SPL meter (i.e., how fast is fast? How slow is slow?)

(b) Select slow response. Measure the level of the following sounds: (a) background noise in the hallway (wait until there are no people walking past. Note: this may be below the level of the SPL meter). (b) A normal conversation, at about 50cm distance (hold the meter in front of you and talk). (c) Yelling, at about 50cm distance.

(c) Practice saying "aaaa" until you can get the SPL meter to reliably hit a target level (within +/-3dB). Now let your lab partner turn the dial away from you (so that you have no feedback), and measure the level of your "aaaa" at the following distances: (a) 25cm, (b) 50cm, (c) 1m, (d) 2m, (e) 4m. In your lab report, plot measured SPL as a function of distance.

Problem 1.2

In this problem, you will continue using the SPL meter; you will also start using a useful acoustic-phonetic analysis program called Praat. You will record and play a number of sound files. If you wish to do so, you are welcome to store any of these sound files to your own netfiles—just open a web browser on the lab computer, and log in to your netfiles account. You should then be able to view these audio files on your own PC, at home: you only need to download a free copy of Praat from Paul Boersma's web page (type "Praat" into any search engine to find it).

Log in to one of the lab PCs. You may log in using the "guest" account, with no password.

Double-click on the "Praat" icon on the desktop. Two windows will open: a "Praat objects" window, and a "Praat picture" window.

(a) In the Praat objects window, choose the "Read" menu, then "Read from file." Use the file browser to navigate your way to the `ECE598AL/lab 1` folder. Open the file `75HzTone.wav`. You should see the object "Sound 75HzTone" appear in the objects window. Make sure that this object is selected, and press the button "Edit." A window showing the waveform and spectrogram will pop up. Play the sound (choose "View"→"Play", or just hit the tab key). What does it sound like? At this point in your lab report, please give me an equation for $p(t)$, the air pressure created by the loudspeakers or headphone when they play back this file. Be sure to specify the angular velocity, amplitude, and phase of the file (in order to verify the phase, zoom in on time zero. For amplitude, you may use the amplitude of the waveform displayed on your screen).

(b) C-weighted SPL measures $20\log_{10}(P_{RMS}/P_{REF})$, where the RMS pressure includes all audible frequencies. A-weighted SPL is frequency-weighted in order to better reflect the loudness of a sound to human ears: middle frequencies are weighted more heavily, while high and low frequencies are weighted less heavily. On the lab PC, in the folder `lab 1`, you will find audio waveforms called `75HzTone.wav`, `150HzTone.wav`, `300HzTone.wav`, `600HzTone.wav`, `1200HzTone.wav`, `2400HzTone.wav`, and `4800HzTone.wav`. As you load these objects, you will notice that they are all the same amplitude. Place the SPL meter about 50cm from the computer speaker, and adjust the speaker volume so that the 1200Hz tone has a C-weighted level, at 50cm, of about 65-70dB SPL. Find the level of the other tones; they should all be pretty close to the same level as the 1200Hz tone. Now switch to A weighting, and repeat the experiment. In your lab report, plot two curves, labeled "A-weighted level" and "C-weighted level," showing the readings on the SPL meter as a function of log frequency.

(c) Plug in the headset microphone. Choose "New"→"Record mono sound" from the Praat objects window. Record yourself speaking. Select the new sound object, open a waveform window, and play it back. Familiarize yourself with the look of a speech waveform.

(d) Practice phonating, with the SPL meter facing toward you, until you can phonate reliably at 60dB SPL, 66dB SPL, and 72dB SPL (you may adjust these levels if other levels are easier for you, but make sure to choose levels that are 6dB apart). Now, while you are phonating at 60dB, choose "New"→"Record mono sound" and record your voice. Repeat at 66dB, and then again at 72dB. Look at these waveforms on the computer monitor. They will not be sinusoidal—instead, they will tend to look like a series of strong pulses (one every 5ms or so), with weaker pulses in between. Try to estimate, by eye, the RMS of each of these waveforms, in the units of the waveform display. In your lab report, create two plots: SPL as a function of waveform peak amplitude, and SPL as a function of estimated waveform RMS, where both peak amplitude and RMS are measured in the units of the waveform display.

(e) Recall that SPL is defined as $L = 20\log_{10}(P_{RMS}/P_{REF})$, where the reference pressure is $P_{REF} = 20\mu$Pa. What are the RMS pressure levels, in Pascals, of the three waveforms you created in part d? What is the relationship between Pascals and the display units – how many Pascals per display unit? (Note that this relationship depends on the volume settings of the recording program; you should not assume that this number will stay the same from week to week, because people sometimes change these volume knobs).