

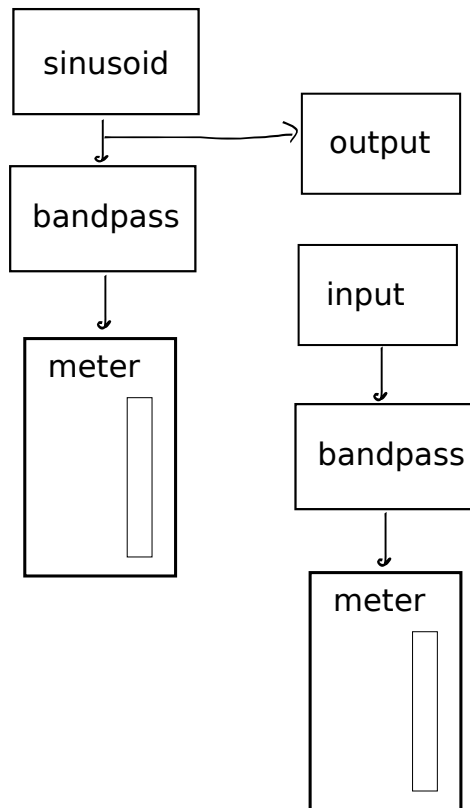
Music 170 assignment 7

1. A sinusoidal plane wave at 20 Hz. has an SPL of 80 decibels. What is the RMS displacement (in millimeters.) of air (in other words, how far does the air move)?
2. A rectangular vibrating surface one foot long is vibrating at 2000 Hz. Assuming the speed of sound is 1000 feet per second, at what angle off axis should the beam's amplitude drop to zero?
3. How many dB less does a cardioid microphone pick up from an incoming sound 90 degrees ($\pi/2$ radians) off-axis, compared to a signal coming in frontally (at the angle of highest gain)?
4. Suppose a sound's SPL is 0 dB (i.e., it's about the threshold of hearing at 1 kHz.) What is the total power that you ear receives? (Assume, a bit generously, that the opening is 1 square centimeter).
5. If light moves at $3 \cdot 10^8$ meters per second, and if a certain color has a wavelength of 500 nanometers (billionths of a meter - it would look green to human eyes), what is the frequency? Would it be audible if it were a sound? [NOTE: I gave the speed of light incorrectly (mixed up the units, ouch!) - we'll accept answers based on either the right speed or the wrong one I first gave.]
6. A speaker one meter from you is paying a tone at 440 Hz. If you move to a position 2 meters away (and then stop moving), at what pitch to you now hear the tone? (Hint: don't think too hard about this one).

Project: *why you really, really shouldn't trust your computer speaker.*

We know from project 1 that computer speakers perform badly at low frequencies, sometimes failing to do much of anything below 500 Hz. But within the sweet spot of hearing, 1000 to 2000 Hz, say, are things starting to get normal? On my computer at least, it's impossible to believe anything at all about the audio system, as measured from speaker to microphone.

In this project, you'll measure the speaker-to-microphone gain of your laptop. but instead of looking at a wide range of frequencies, we're interested in a single octave, from 1000 to 2000, in steps of 100 Hz. The patch is somewhat complicated. You'll make a sinusoid to play out the speaker (no problem) but then you'll want to find the level, in dB, of what your microphone picks up. Since it will pick up a lot of other sound besides the sinusoid, you'll need to bandpass filter the input signal from the microphone to (at least approximately) isolate the sinusoid so you can measure it. Here's the block diagram I used:



To use it, set the Q for both bandpass filters to 10. Set the frequency of the sinusoid, and the center frequencies of both filters, to 1000. You should notice that the gain of the filter isn't one - this is why you have to monitor the signal you're sending out the speaker through a matching filter, so that you're measuring the sinusoid's strength the same way on the output as on the input.

Now choosing a reasonable output level, and pushing the input level all the way to 100 (unity gain), verify that you're really measuring the input level in its meter (by turning the output off and on—you should see the level drop by at least about 20 dB when it's off. If not, you might have the filters set wrong, or perhaps Pd is mis-configured and looking for the wrong input.) Also, don't choose an output level so high it distorts the sinusoid - you should be able to hear if this is happening. Most likely an output level from 70 to 80 will be best.

The gain is the difference between the input and output levels (quite possibly negative; that's no problem). Now find the gain (from output to input, via the speaker and microphone) for frequencies 1000, 1100, 1200, ..., 2000 (eleven values). For each value, be sure you've set all three frequencies (the sinusoid and the two filters). Now graph the result, and if you've got less than 15 dB of variation your computer audio system is better than mine.