Music 170 assignment 8

[These are all review problems.]

1. A square plate is vibrating sinusoidally to create a 'beam' of sound. (Idealize this as in chapter 7 to a 1-foot line segment). At what frequency must it vibrate so that the beam spreads 30 degrees to either side (that is, so that the intensity drops to zero 30 degrees off axis)?

2. If you wish to form a beam with the same dispersion (spread), at a frequency two octaves lower, by what factor would you have to increase the dimensions of the square plate?

3. How many watts should you emit from a speaker (assuming the sound goes equally in all directions) to reach a sound level of 80 dB at a distance of 10 meters? (Assume you're away from any reflecting objects so that you only need consider the direct sound.)

4. What is the wavelength, in air, of the musical F above A440 (the musical A defined as 440 Hz.)? (You can answer in feet with c=1000 feet per second, or in meters at 343 M/sec.) Assume we're using the tempered scale.

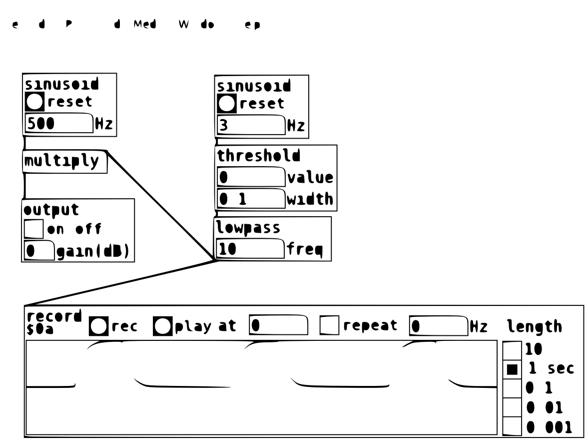
5. What is the average power of a sinusoid whose peak amplitude is 2?

6. How fast must a sound source be moving away from you so that Doppler shift makes the pitch of the sound decrease by one octave?

Project: *low-pass filtering as a smoothing operation.*

Perhaps the most fundamental and important tool in dealing with sounds is controlling amplitudes by applying a gain to a signal. You do this any time you change the volume on your phone, for example. It's not as simple as it sounds. If you change the gain of an amplifier too quickly the sound will not just change amplitude but will often make an audible clicking sound as it does so. This is a major problem if the quality of the sound matters.

Here is a patch to demonstrate/test this idea:



The three objects on the left are a straightforward sinusoid with amplitude control via a "multiply" object. On the left, we're generating a signal to turn the sinusoid on and off, by thresholding another, slow sinusoid (the one at top left.) The threshold signal is a series rectangular pulses, three per second, each one 0.1 seconds long.

We're using a "lowpass" object to smooth the edges of the pulses. The cutoff frequency of the low-pass filter determines the sharpness of the edges. In the picture above, the cutoff frequency is set very low to exaggerate this effect so that you can see it. You might want to try values between

2 and 20 Hz. to see how they affect the picture you get from the “record” object at bottom.

The assignment is to find out how much smoothing you need to be able to turn the sinusoid on and off without hearing an audible ”click” or ”pop”. This will turn out to depend on the frequency of the sinusoid.

First, set the frequency of the sinusoid (at upper left) to 2000. Adjust the low-pass filter’s cutoff frequency to 20000 Hz. (essentially no filtering at all) and enjoy the clicks. Then drop the frequency to 5000, 2000, 1000, 500, etc., until you find the value at which you just hear a sinusoid turning on and off without artifacts. (Don’t be a perfectionist... you can always convince yourself you hear a clock or pop, just get it so that it’s not easily audible.)

Now do the same thing with the sinusoid set to 500 Hz, and finally repeat the experiment after replacing the sinusoid with a “noise” object. What are the three values you had to set the low-pass filter to to hear “clean” turn-ons and turn-offs for the three situations (2000, 500, noise)?