Music 170 / ICAM 103: Formulas and Problem Set #8 (due Dec. 4)

Formulas:

Sound intensity (defined in Homework 4 as power per unit area) goes down with distance. If the source of a sound sends it in all directions equally, then the intensity I is related to the total power W by:

$$I = \frac{1}{4\pi r^2} W$$

Intensity can be converted to the level (in dB) by the formula in homework 4. See Rossing Chapter 6.

Rossing chapter 23 gives this formula for predicting room reverberation times:

$$\text{RT60} = 0.161 \frac{\text{sec}}{\text{meter}} \frac{V}{A} = 0.161 \frac{\text{sec}}{\text{meter}} \frac{V}{Sa}$$

where V is volume, A is "absorptive area", S is total surface area, and a is the average *absorption coefficient* of the surface. This can (usually does) depend on frequency.

Beam width. Idealizing a source as a rectangular plate L units wide, a sinusoid with wavelength λ makes a beam of angular width equal to:

$$\theta = \arcsin\left(\frac{\lambda}{L}\right)$$

(This is corrected from a previous, wrong formula!)

Soundfiles. Suppose a soundfile has b bits per sample, c channels, and a sample rate of R. The signal to noise ratio of the soundfile depends on b. In decibels, it is:

$$\text{SNR} = 20\log_{10}(2)b \approx 6.02b$$

The maximum frequency the soundfile can hold is $R/2$.

Problems

1. A professor is speaking 1 meter away from you. You move to a seat 4 meters away. By how many decibels does the level of the direct sound decrease?

2. A room is in the shape of a cube, 10 meters on a side. The wall absorption coefficient is 0.5. What is the predicted reverberation time (RT60)?

3. Suppose a room has an RT60 of 2 seconds at low frequency and 1 second at a high frequency (say 5000 Hz). If a short sound is made in the room, how much more are the high frequencies attenuated than the low ones after one second?

4. A speaker is 1/2 meter wide. Assuming its surface is a flat rectangle (a bad way to design a speaker!) how wide, in degrees, is the beam at 1000 Hz.? 10000 Hz.?

5. Suppose a performance of Beethoven's ninth symphony lasts 70 minutes You want to record this at a professional-sounding 144 dB signal-to-noise ratio, you want to capture all frequencies up to 25,000 Hz., and you are recording 16 channels. How many bits of storage will this take? How many gigabytes is that?