Homework 7, HONS 280 (Physics of Sound and Music)
Spring 2020
DUE Friday, February 21st

1. An isotropic (radiating equally in all directions) point sound source emits a pure tone at 500 Hz. The acoustical power of the emission is 0.17 Watts (this is actually a substantial amount.) The temperature is 18°C and the air has a density of 1.15 kg/m^3. (This is a slightly different value than we usually use in Physics, but that's because I'm envisioning this occurring at an altitude above sea level). Calculate:

   a) The sound power level (L_W) in dB.
   b) The sound intensity level (L_I) in dB a distance 14.0 meters from the source. Leave your answer to the nearest tenth of a dB.
   c) The sound pressure level (L_p) in dB a distance 14 meters from the source (do not assume $\rho c = 400$ in proper units; you have enough information to calculate it. You may need to retrieve the speed-of-sound-in-air-as-a-function-of-temperature equation, however). Leave your answer to the nearest tenth of a dB.
   d) The approximate loudness level in phons a distance 14 meters from the source.
   e) The approximate loudness level in Sones a distance 14 meters from the source. (Use the loudness-level based equation to find this, not the pressure-based equation).

2. Two independent sources cause sound intensity levels of 87.1 dB and 85.7 dB at a distance of 31 meters from the sources.

   a) What is the combined sound intensity level in dB?
   b) Assuming these sources are both emitting pure tones at frequency 5kHz, what is the loudness level in phons? (You may assume $L_I = L_P$).

3. Let us say you just bought a new sound-system for your car, and you want to make it sound as loud as possible to show it off. Generally speaking, you know that disorganized "noise" sounds louder than organized sound for the same sound pressure intensity (see figure 6.8 in your text to verify), so you opt to subject an audience to some noise to impress them with how loud your speakers are. Based on your knowledge of the biology of the human ear (in particular critical bands) and information found in chapter 5, should you play broadband or narrow band noise for your audience to impress them more? Explain your answer.

4. Let us assume that every member of an orchestra plays with equal sound pressure level (a dubious assumption, but this is a back-of-the-envelope calculation). What would the difference (in dB) be for a single player playing vs. the entire 120 piece orchestra?

5. Let us say you stand 5 meters away from a speaker that has an 8 Watt electrical output and an efficiency for turning electrical energy into acoustical energy of 0.71% (this is actually a pretty realistic value; most speakers convert less than 1% of the electrical energy into acoustical energy). Also assume the speaker emits this sound – not in a sphere, but in a "cone of sound". In this abstraction, no sound is heard outside the cone (this isn't totally realistic, but it is better than assuming a hemisphere or a sphere. The angle α as illustrated in the figure for the cone is $\pi/6$ (or, if you prefer degrees, $30°$). You may assume all of the acoustical energy is distributed evenly over the end of the cone, and you may assume that you are far enough away from the vertex of the cone that the curvature of the advancing acoustical wavefront is negligible.

   a) What is the sound intensity level at your ear (in dB) if you are standing 12 meters away from the speaker/cone vertex?
   b) What would the sound intensity level be at your ear if you walked an extra 5 meters further away (in dB)?
   c) What distance would you need to stand from the speaker so that the sound level matched a normal conversation at 1 meter (see table 6.1 of your text)?
   d) How far would you have to walk away for a 1kHz signal to be just audible? (Assuming no masking phenomena are going on, and you are in an otherwise perfectly quiet environment)?
   e) Your answer to part (d) should be clearly crazy. Explain why you get such a crazy result. What are you ignoring in your computation?