

Assignment 6
Physics of Music - 2016
Physics 341

1 a) I attended the Marriage of Figaro a few years ago, and found that hearing the bass while he was singing his lower notes was much more difficult than hearing the tenors and the women. Could there be some Physics reason for this? What is it?

b) Why is an (unpowered) megaphone useful (consider the size of the radiating area)? Why do singers tend to sing with their mouths wide open? (It is not for the looks!)

c) Why, when you scream for help, do you open your mouth wide and scream at a high pitch?

2. Figures 1 and 2 are the polar plot of the sound radiation intensity given off by a vibrating diaphragm in a wall, at various frequencies. what is the the relative intensity both as a ratio to straight ahead and as dB (relative to straight ahead) of the sound given off at 40 degrees for a frequency of twice the knee frequency? At 70 degrees? What are the relative intensities (compared to straight ahead) of the sound given off at 5 degrees and at 30 degrees for a frequency of eight times the knee frequency.

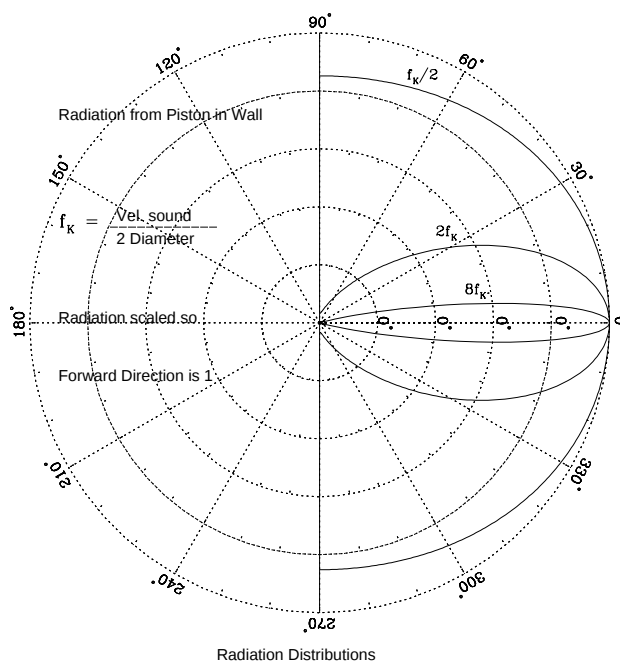


Figure 1

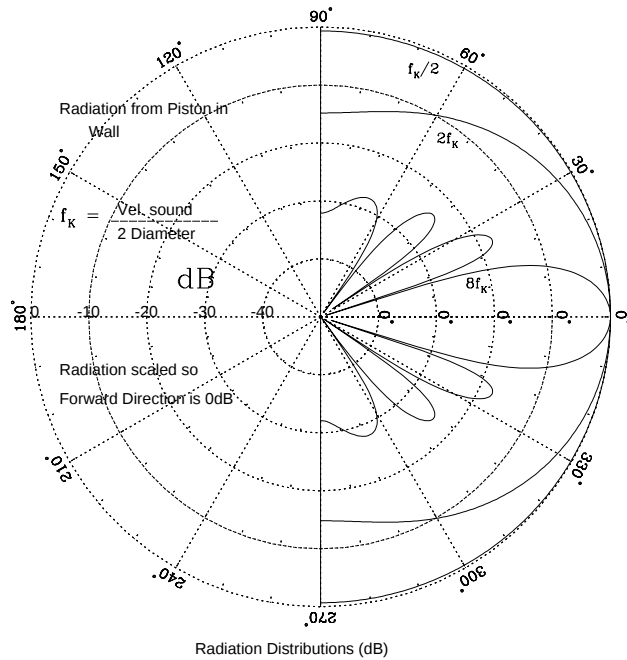


Figure 2

3) The critical band is the range of frequencies around which the vibration on the basilar membrane overlaps (ie, if one has two frequencies, the widths of the region which each causes to vibrate overlap with each other). This is taken to roughly be a minor third (ie, if two frequencies differ by less than a minor third, their regions of membrane excitation overlap). Consider the series of harmonics of a note. By which harmonic do successive harmonics have overlapping excitations on the basilar membrane?

4)a) How much sharper or flatter (give a ratio) is a just major third (5/4) to two Pythagorean whole tones?

b) Three major thirds (four semitones) could be said to be an octave (twelve semitones). How mistuned would that octave be if each of those major thirds were just major thirds?

5)a) A workman is exposed to a sound of 60dB for 7 hours, and 100dB for one hour without hearing protection. What is the average energy rate of the sound that he received during the course of the day? The Workman's compensation says that if the average energy rate is higher than 80dB during 8 hours, hearing protection must be provided. Is the company in compliance?

b) The standard in BC for Railway workers is that the average noise level must not exceed 87dB for an 8 hour day. BC mandates the 3dB rule, namely that the time of exposure must be halved for each 3dB rise in the average noise

level. How long could a railway worker work in a place (eg a disco) with an average noise level of 120dB? In Ontario, the requirement is that the worker is allowed to be exposed to 90 dB for an 8 hour day, and that the time is halved for each 5dB rise in noise level. How long would a Ontario worker be allowed to work in that same disco.

6) Two notes, tuned a equal tempered perfect fifth apart are played together. How many beats per second would you get between the first three harmonics of the two notes that have the same frequency in Just tuning if the lower note was 220Hz?

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