Name: ______________________________

Other group members: ______________________________

Tutorial #5

PHYS 1240: Sound and Music

Friday, July 19, 2019

Instructions: Work in groups of 3 or 4 to answer the following questions. Write your solutions on this copy of the tutorial—each person should have their own copy, but make sure you agree on everything as a group. When you're finished, keep this copy of your tutorial for reference—no need to turn it in (grades are based on participation, not accuracy).

1. When telephones were first being developed by Bell Labs, they realized it would not be feasible to have them detect all frequencies over the human audible range (20 Hz - 20 kHz). Instead, they defined a frequency response so that the highest-pitched sounds telephones could receive is 3400 Hz and lowest-pitched sounds they could detect are at 340 Hz, which saved on costs considerably.

   a) Assume the temperature in air is 15°C. How large are the biggest and smallest wavelengths of sound in air that telephones are able to receive?

   b) Most adult voices have frequencies below 340 Hz. How is it then that voices are able to be transmitted through telephones with such a poor frequency response?

   c) Suppose you hear the following frequencies being transmitted through the telephone: 375 Hz, 625 Hz, 875 Hz. If these are all part of some harmonic series, what is the fundamental frequency?

2. The Precise Tone Plan for North American telephones has standardized the dial tone so that it is always composed of two sine waves with frequencies of 350 Hz and 440 Hz.

   a) Listening to these two tones, it may appear as if there is a third note, with a frequency caused by periodic changes in the sound's amplitude. What is this frequency, and what is its cause?

   b) Calculate the frequency ratio between the upper and the lower dial tone frequencies, expressing your answer as a decimal.

   c) Determine about what musical interval this gives. To do so, start with 350 Hz and multiply by $2^{1/12}$ to go up a half step. Then, multiply by the same factor again, and repeat until you get close to the upper frequency. How many half steps do you find, and which musical interval would that be?

   d) Is the musical interval you found greater than, exactly equal to, or less than the justly-tuned version of that interval? Do you think this would sound dissonant or consonant?

3. The tones produced when pressing a key on a telephone are standardized as per the table below—two tones are played, one high-frequency tone and one low-frequency tone. The low-frequency component is determined by the key's row on the telephone, and the high-frequency component by the key's column, as shown. None of these are pure, consonant intervals, but calculate the frequency ratios for the 4 key, 8 key, and # key to show that they give roughly the same ratio. Are they close to any musical interval?

	1209 Hz	1336 Hz	1477 Hz
697 Hz	1	2	3
770 Hz	4	5	6
852 Hz	7	8	9
941 Hz	*	0	#

4. For the final problem, we will consider a pentatonic scale, consisting of 5 notes per octave.

   a) First, find the frequencies of a pentatonic scale with equal temperament. To do this, we can go through the same process as discussed in class, except instead of multiplying by $2^{1/12}$ for every interval, we now need to multiply by $2^{1/5}$, so that we'll reach an octave (2/1) after five notes instead of twelve.
   Label your notes 1, 2, 3, 4, 5, and 1' (the first note but an octave higher). Let the frequency of 1 be 261.5 Hz, and calculate the frequencies of the other five notes.

   b) The table below shows frequency measurements for two instruments within a gamelan ensemble, the barung and the demung. Both are xylophone/bell-like instruments, so based on the information given in the table, which instrument is larger?

   c) Compare the demung's frequencies to your equal temperament. Are they the same? In particular, is a gamelan's octave a pure 2/1 ratio, or is it stretched or squished?

Note	Barung	Demung
1	524.5 Hz	261.5 Hz
2	600.3 Hz	301.5 Hz
3	688 Hz	343.4 Hz
4	803 Hz	399 Hz
5	918.6 Hz	456.5 Hz
1'	1055.5 Hz	524.5 Hz