Assignment XII, HONS 280 (Physics of Sound and Music)
DUE (VIA EMAIL TO ME AT LarsenML@cofc.edu) prior to 2 PM on 4/3/20

Please type your answers to the following. Showing work is optional, but the only way to get partial credit on a numerical answer.

If you don't think we've talked about some of these ideas in class (and we might not have), you might want to read chapters 9 and 10 to help you out.

1. How many cents does the syntonic comma correspond to?
2. Two pitches on a touch-tone phone are 941 Hz and 697 Hz.
   a) What is the frequency ratio between these two pitches?
   b) How many cents apart are they?
   c) What is the closest musical interval to this frequency ratio?
   d) If you play these two frequencies at the same time, would you perceive the interval in part (c) as sharp or flat of the true interval?
3. Your textbook talks about the resonances of the guitar body. The discussion there is modestly technical, but let's take a step back and think about modeling it a bit more crudely. Recall that the resonant frequency of a Helmholtz resonator can be written as:

$$f = \frac{v}{2\pi}\sqrt{\frac{a}{V\ell}}$$

   where v is the speed of sound in air, a is the area of the next, ℓ is the length of the neck, and V is the volume of the resonator. A guitar isn't shaped exactly like a typical Helmholtz resonator, but let's see if it gives a reasonable answer here. Assume that ℓ is equal to the thickness of the wood (about 2.5 mm according to your text), and use a reasonable value for a (the area of the sound hole on a guitar) and v (the speed of sound in air). What would the volume of the guitar body have to be in order to get a fundamental resonance at the lowest string (tuned to E_2). Comment on whether this seems reasonable.
4. What is the rule of 18? How can it be improved upon?

5. A hypothetical guitar-like instrument has a distance of 0.72 meters (this is intentionally not really what most Guitars are, just so that you can't just google the answer to this question).

   a) How far *should* it be between the 3rd and 4th fret (if you treat the nut to be the 0th fret).

   b) Let's say that placing frets closer than 1 cm from each other is impractical. (I actually don't know what this number really should be, but 1 cm seems like a decent order-of-magnitude estimate). If this is true, how many frets could you put on this hypothetical guitar-like instrument?

   c) How far away from the bridge would this final fret be?

6. You have a guitar string of length L. You are able to create a "harmonic" by lightly pressing down at the string at a distance $L/4$ from the "nut" (where we will assume the strings end). You can also make a particular pitch by pressing down firmly at the same place and playing the guitar in the normal fashion.

   a) Which pitch will have a higher frequency – the played note or the harmonic?

   b) What will the ratio between the two frequencies (the played note and the harmonic) be?

   c) What musical interval does this frequency ratio correspond to?

   d) Where else could you make a node to create the same harmonic on the string?