Math 5: Music and Sound. Homework 5

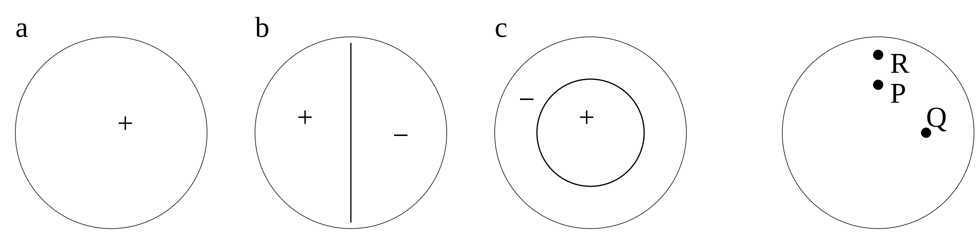
due Fri May 4 ... but best if do relevant questions after each lecture

Note that the first two questions are good review for the Midterm!

1. These quick results will be useful in estimating decay times of partials:
   (a) How many dB does the intensity of *any* damped oscillator drop in one decay time τ?
   (b) How many decay times do you have to wait until it is 10 dB less than it started?

2. Estimate decay time of the damped oscillation `tuningfork_decay.ogg` recorded from a tuning fork.
   (a) Use `audacity` to decide where amplitude is down by $1/e = 0.37\cdots$
   (b) Now measure decay time more accurately by switching to `Waveform (dB)` on the pulldown menu on the track name (or using `show Intensity` in `praat`). How long does it take to get to 30 dB less intensity than it started? Compute τ from this.
   (c) Use your accurate decay time, and another measurement, to compute the Q factor (big, eh?)

3. Nodal lines (and the phase of the vibrations) are shown for three modes a,b,c of a circular drum, *e.g.* a tabla or conga.



   If the drum is hit at the location P, describe which modes a, b, of c will be excited and which not. Repeat for Q and R. [BONUS: Of the modes excited each time, which will be more excited?]

4. (a) Compute the wave speed in a violin string of mass density 0.001 kg/m and tension 100 N.
   (b) What wavelength does a frequency 440 Hz have on this string? (Careful: I am not asking for the wavelength *in air*)
   (c) How long should a violin string be made so that the fundamental frequency of this string is 440 Hz (the A string of a violin)? (is this about right?)

5. Draw pictures of the first few modes of an ideal string, labelling nodes (N) and antinodes (AN).
   (a) Imagine the string is struck 1/3 of the way along. What excitation amplitudes $\alpha_1, \alpha_2, \ldots$ do you expect this to cause? (work out the first *e.g.* 6 then spot the pattern.
   (b) Say the fundamental is 330 Hz (the top guitar string). Sketch the spectrum (partials and their strengths) produced by this struck string.
   (c) Instead you place your finger 1/4 of the way along the string while plucking the string at some general place. Which frequencies will be present? What pitch will you perceive?

6. Record a non-musical or musical object which demonstrates several complex vibration modes when you hit it *percussively*, and upload as an Aural Posting. You will be able to tell you have several modes because you will find several partials in the spectrogram, which usually won't be harmonically related (therefore, often a bell, clang, or drum sound). Briefly discuss partial frequencies and decay times (estimate[1] with `praat` and the results from Question 1) in your posting. Kitchens, metalwork, music shops, are good places to explore…

[1] I don't know a good way to do this when partials have a range of decay times—any of you know or develop a good way?