Exam - Monday 3pm

Final review

- **Subject matter**
  - **Production, Propagation, and Perception**
- **Tone**
  - **Strictly conceptual**
  - There will be only conceptual questions
  - However, where equations describe the relation of relevant quantities I will expect you to integrate them into your discussion.
    - For example, 'tuning the violin, you increase the tension in the string. This increases the wave speed in the string and so increases the frequencies (pitch) of standing waves that fit on the length of string. This relationship can be seen in v = … '

- **Grading Criteria**
  - I will be testing for how complete your understanding is of the concepts & processes involved in the ' 3 P's' of musical sound.
    - production of a musical sound
    - its propagation through a room (and interaction therewith),
    - its reception at the ear, and finally our perception of it.
  - I'll also specifically be looking for you to connect these subjects to your classmate's presentations – you don't need to talk about *everyone's* presentation, just make a few appropriate connections
- **Production Specifics**
  - I will ask you to discuss an acoustic (i.e., not electronic) instrument of your choosing from the families of string, wind, or voice (not percussion.)
- **Perception Specifics**
  - Look back at exam 2's long question about how the ear works, the *exact* questions you get on the final may be a little different, but if you feel like you've mastered that question, you'll be in pretty good shape for what I'll ask on the final.
- **Recommendation**
  - I encourage you to look at the posted ppt presentation slides of your classmates – many of these speak to the production, propagation, and the perception of sound.
  - Preparing for this test, think of it like you would any other conceptual test - I'm mostly going to be looking for your knowledge and understanding of the big picture. The understanding is what I'll be most interested in. There are some key elements and then there are many fine details. In grading, I will make the distinction, so in preparing for the test, you should too. You've got to address the big points. Among the little ones, you hit some and skip others.
- Note: this is your opportunity to show me what you know & understand. I'm definitely expecting the key points to be covered, but there's also plenty of room to wow me with your understanding of related details that aren't key. On previous exams, I've asked very focused questions and when some of you've given me interesting and informative answers that were off-topic, I've had to mark off; on this test, you'll have more room to highlight what you know.

Here is an outline of the acoustic process. Be able to flesh it out and explain the steps for a particular instrument.

Production

It is important to be able to trace the motion,

- starting at the non-musical input (striking a key, dragging a bow, plucking a string, or exhaling a breath),
- through the transfer to something that, by virtue of its geometry and material properties (length, tension, mass density), preferentially moves at a certain family of frequencies (often it's a harmonic series) -i.e. resonates.
    - The motion of this piece is either identifiably musical (as for a string), or at least periodic (the motion of the vocal cords)
- The motion is then transferred to the 'body' of the instrument where the sound is further refined (for example, subtly the body of a violin vibrates best near certain frequencies and thus strengthens those, more dramatically the shape of the vocal tract determines what vowel is produced, and quite dramatically the length of a wind instrument determines how long it takes an air pulse to perform a round trip and thus what frequency it will shift the edge tone to and so what pitch is played.)
- It will be important to know how an instrument designer and performer can change the geometry or material properties to effect the sound produced (timbre, pitch, loudness).
- It will also be important to be able to communicate the changes in timbre in the language of physics, i.e., in terms of changing the spectra

Propagation

There are a few key ways that sound is altered as it propagates through a room to a listener. Be prepared to explain these and to explain how they can be exploited to manipulate the sound propagation and improve the audience's experience.

- These alterations are through the sound's spreading as it radiates out from the source and the corresponding attenuation,
- it's reflection from surfaces, and its adsorption into or transmission through the surface.

Perception

Here we've got the workings of the ear. (Not to fear, there will be a labeled picture of it.) Key here are

- the action of the eardrum, the amplification through the ossicles levering and through the reduction in area through which the push is transmitted,
- the rolls of the windows and of the perillymph fluid, the roll of the basilar membrane.
- It will be important to be able to explain how all this mechanical motion is finally translated into different signals for different frequencies, and so the ear resolves the complex motion of the air, a complex sound, into its simple components.
- I will not be looking for a discussion of any debunked aspects of different theories of hearing.

Beats, phantom harmonics, and localization fall under the heading of 'extra details.' As I've indicated above, I'll be keen on the key elements of production, propagation, and perception, but I'll also be looking for a number of details. Which details you discuss is your choice.

- **Equations**
  - You will not be asked to *use* any equations, but you will be expected to cite them when applicable. Here are the equations you will be given with the final.

Useful Geometric Relations

For circles: $C = 2\pi R$, $A = \pi R^2$ For Spheres: $A = 4\pi R^2$, $V = \frac{4}{3}\pi R^3$

Physical Relations

Fundamental

$$v \equiv \frac{d}{t} \qquad v_{wave} \equiv \lambda \cdot f \qquad f \equiv \frac{1}{P} \qquad pressure \equiv \frac{Force}{Area} \qquad f_B \equiv |f_1 - f_2|$$

$$I \equiv \frac{Power}{Area} = \frac{Energy}{Area \cdot time} \qquad S.I.L._2 - S.I.L._1 \equiv 10dB \cdot \log\left(\frac{I_2}{I_1}\right) \Rightarrow \frac{I_2}{I_1} = 10^{\frac{S.I.L._2 - S.I.L._1}{10dB}}$$

$$T_r \approx 0.16\, {}^{s}/_{m} \cdot \frac{Volume}{Area_{effective}} \text{ where } Area_{effective} = \alpha_1 A_1 + \alpha_2 A_2 + \ldots$$

Under Certain Conditions

$$v_{sound} = 344\, {}^{m}/_{s} + 0.6\, {}^{m}/_{(s\cdot°C)} \cdot (T_C - 20°C) \qquad v_{sound} = 344\, {}^{m}/_{s} + \frac{1}{3}\, {}^{m}/_{(s\cdot°F)} \cdot (T_F - 68°F)$$

$$P = 2\pi\sqrt{\frac{m}{k}} \qquad f_n = nf_1,\ \text{n} = 1, 2, 3, \ldots \qquad \Delta t = \frac{3r}{v_{sound}}\sin\theta \qquad \frac{Force_1}{Force_2} = \frac{x_2}{x_1}$$

$$v_{wave} = \sqrt{\frac{F}{{}^{M}/_{L}}}$$

$$L = (¼ + n/2)\lambda \qquad L = n\frac{\lambda}{2} \qquad f_n = n\frac{1}{2L}\sqrt{\frac{F}{{}^{M}/_{L}}} = nf_1,\ \text{n} = 0, 1, 2, 3, \ldots$$

$$\frac{I_2}{I_1} = \frac{Area_1}{Area_2} = \frac{r_1^2}{r_2^2} \qquad \frac{I_2}{I_1} = \frac{Power_2}{Power_1} \qquad \sin\theta = 1.22\frac{\lambda}{D}$$