Assignment V, PHYS 150 (Physics of Sound and Music)
Hearing
Due February 7, 2014

(We didn't talk about all of these things during class; the things we didn't talk about in class can be readily found in your text – primarily from chapter 5. Also note – there are questions on both sides of the paper.)

1. Are the acoustical low frequencies detected by the hairs in the basilar membrane that are (a) closest to or (b) furthest from the stapes?
2. Spend a paragraph or two discussing how we would view the world differently if our senses acted on a linear instead of a logarithmic scale.
3. What is a critical band?
4. If we take the notion of "quality factor" from resonance and apply it to critical bands for hearing, we can define a new variable:

$$\tilde{Q} = \frac{f_\circ}{\Delta f}$$

where $f_\circ$ is the center frequency of the band, and Δf is the critical bandwidth associated with that center frequency.

   a) Approximate $\tilde{Q}$ for $f_\circ = 100$ Hz, $f_\circ = 500$ Hz, $f_\circ = 1000$ Hz, $f_\circ = 5000$ Hz, and $f_\circ = 10000$ Hz.
   b) Use your answers to part (a) to explain how critical bands *seem* narrower at higher frequencies, despite the fact that the actual size of the frequency band (in Hz) actually increases at higher frequencies.

5. Explain why you sound differently when you hear yourself talking vs. when you hear a recording of yourself on a tape recorder.
6. It is well known that "diffraction" effects start to become relevant whenever the physical size of an object/obstacle/hole/item gets to be around the size of the wavelength of the wave in question. Use this fact to justify why the human ear is unable to use direction to identify the source of sounds above about 1 kHz. (You are likely to need to make a calculation here to justify your point).

7. Let us say you have two speakers located at two different locations. Let us assume the speakers are reasonably far apart. What is the minimum distance apart the speakers would have to be in order for direct sound transmission from them to sound like separate sources? (Hint – check p. 90 of your text and read up on the "precedence effect").

8. Hypothetically, let us say that you are standing outside on a windless day. While looking straight ahead, a gunshot goes off directly to your right. About how much longer does it take the sound to get to your left ear than your right ear?

9. An eardrum can (very crudely) be modeled as a circular membrane with radius about 4 mm. During normal conversation, the sound pressure variations reaching your eardrum are about 10 milliNewtons per meter squared (0.01 per meter squared). What, then, is the total force on the ear during a normal conversation? (To gain some sense of perspective, a paperclip has a mass of nominally 1 gram, so it applies a force of 0.01 Newtons when sitting on a table-top).