L105/205 – Phonetics
Scarborough

Assignment 2
due 10/25/05

ACOUSTICS EXERCISE

1. The waveform shown below is of the word "goodbye" [gʊd'baɪ] spoken more or less in monotone. Below it are two sections of the waveform on an expanded time scale. One section is taken at time (1) and the other, at time (2).

   (a) What is the fundamental frequency?

   (b) What are the frequencies of the next 5 harmonics?

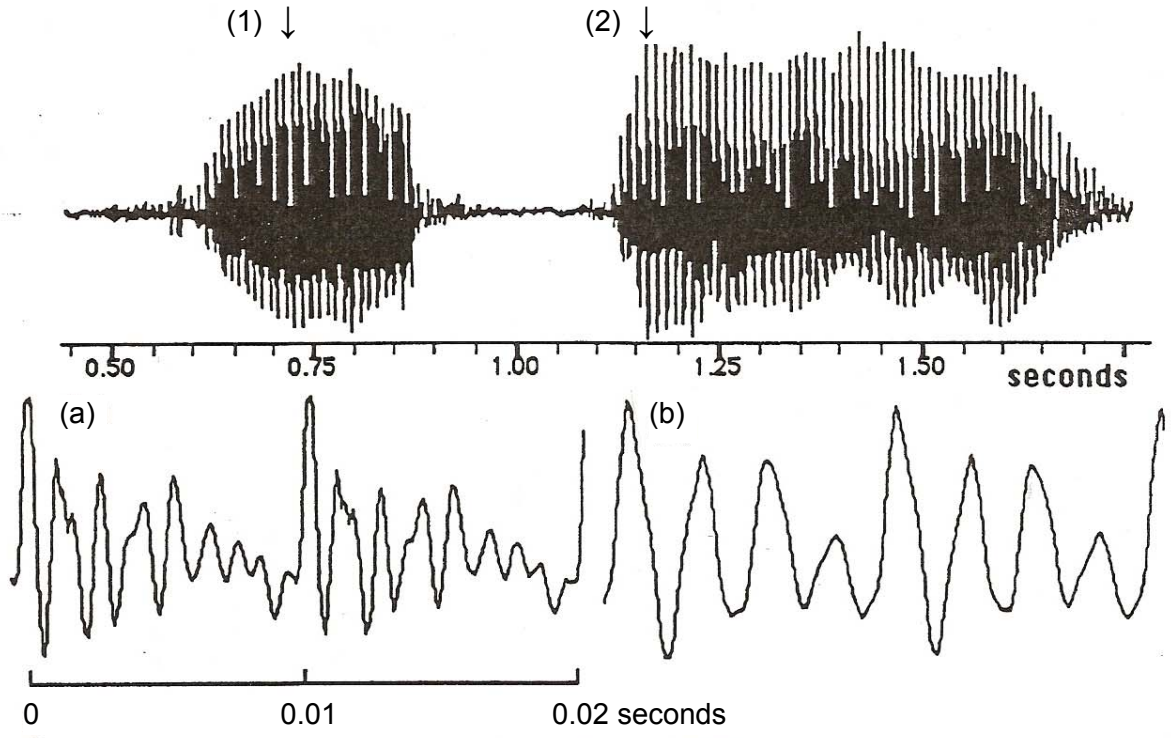
   (c) Without counting, approximately how many glottal cycles make up the second vowel? (Explain how you came to your conclusion.)

   (d) What is the approximate frequency of the first formant in each of the two wave sections? (Think about what effect individual wave components had in wave addition.)

   (e) Which zoomed-in waveform (a or b) is from which point (1 or 2)?

   (f) Sketch approximate line spectra of these waves, up to 1500 Hz (so you may ignore any formants above F1).

   (g) If the speaker raised his or her voice an octave, what would be the answers to (a)-(d)?



2. Suppose you are planning to digitize a recording. You want to minimize the sampling rate for memory reasons, but you need to be able to measure the first three formants of a schwa vowel produced by the speaker, who is an average-sized male. What sampling rate should you use? Explain. (There is not one *exact* correct answer to this question.)

3. A speaker has an F1 of 550 Hz for [ə].

   (a) What is the length of the speaker's vocal tract (assuming that the speed of sound is 35,000 m/s)?

   (b) If the same speaker has an F1 of 865 Hz for [a], what should F2 be (ignoring effects of acoustic coupling, and assuming that F1 is a back cavity resonance)?

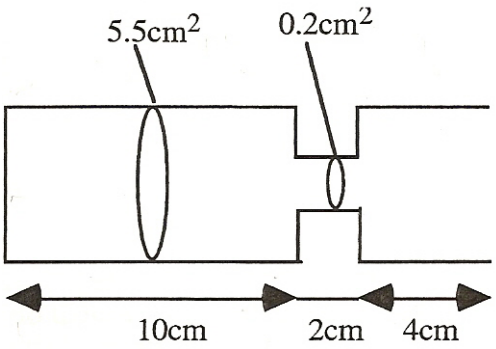
   (c) Does this seem like a reasonable value for F2? In what way might acoustic coupling help to explain any discrepancy from the expected formant values?

4. (a) What is the size of an analysis window (in ms) if the sampling rate is 22 kHz and the window contains 512 samples?

   (b) How many samples are in a 20 ms window if the sampling rate is 22 kHz?

5. Sound waves reach the eardrum through the ear canal. Given that the ear canal is a tube of about 2.5 cm long, open at one end, what will the effect on sound waves be? (Your answer should include some numbers.) Given what you know about speech sounds so far, might this affect speech perception? Say why or why not.

6. The figure below shows a simple tube model for the high front vowel [i]. F3 is the first resonance of the front cavity, F2 is the first resonance of the back cavity, and F1 is the Helmholz resonance of the back cavity and constriction.



The dimensions of this vocal tract are appropriate for an adult male. A typical female vocal tract might be about 90% of this size.

(a) Ignoring any effect of acoustic coupling, what are the proportional changes in F2 and F3 if the dimensions of this vocal tract shape are shorted by this amount? (You shouldn't need to calculate the actual formant frequencies to work this out.)

(b) What is the proportional change in F1 if all dimensions (including constriction length *and* tube widths) are reduced by this amount?

Peterson and Barney (1952) measured average formant frequencies for English vowels spoken by women and men. Average values for [i] are as follows, together with the ratio of female/male formant frequency, for each formant:

	F1	F2	F3
Males	270	2290	3010
Females	310	2790	3310
ratio	1.15	1.22	1.10

(c) How do the ratios for each formant compare with the predicted results of shortening the vocal tract calculated in (b)? Look at how the observed values of the ratios for each formant compare to each other and how your calculated values of the ratios for each formant compare to each other, and mention any differences.

(d) Physiological data indicates that the female vocal tract is not uniformly smaller than the male vocal tract. Generally the pharynx is smaller relative to the mouth cavity in females, so the difference in pharynx size between males and females is bigger than the difference in mouth size (Chiba and Kajiyama, 1941). Tell how this fact can help explain the discrepancy between observed and predicted female/male ratios for F2 and F3. (The story for F1 is different.)