

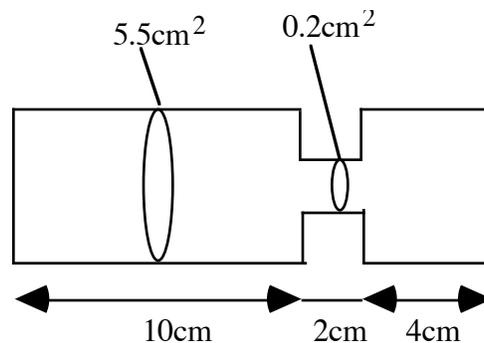
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24.963 Linguistic Phonetics
Fall 2005

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Acoustics Assignment 2: Due 10/14

1. We are planning to digitize a recording. We want to minimize sampling rate for memory reasons, but we need to be able to measure the first three formants of a 'schwa' vowel produced by the speaker, who has a vocal tract of about 15 cm in length. What sampling rate should we use? (Explain).
2. Sound waves reach the eardrum through the ear canal (or external auditory meatus). Given that the ear canal is a tube of about 2.5cm long, open at one end, what effect will it have on sound waves? (Be as precise as possible - i.e. use a simple calculation to estimate the effect).
3. The figure below shows a simple tube model for the high front vowel [i]. Ignoring the effects of acoustic coupling, F3 is the first resonance of the front cavity, F2 is the first resonance of the back cavity, and F1 is the helmholtz 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.

- (i) What are the proportional changes in F2 and F3 if the dimensions of this vocal tract shape are shortened by this amount? (You shouldn't need to calculate the actual formant frequencies to work this out).
- (ii) What is the proportional change in F1 if all dimensions are reduced by this amount (including constriction length and tube widths - NB cross-sectional areas will be reduced in two dimensions)

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 female/male formant frequency, for each formant:

		F1	F2	F3
[i]	Males	270	2290	3010
	Females	310	2790	3310
	Ratio	1.15	1.22	1.10

- (iii) How do the relative magnitudes of the ratios for each formant compare with the predicted results of shortening the vocal tract, calculated in (ii)? (I.e. don't worry too much about the absolute values of the ratios. How do the observed values of the ratios for each formant compare to each other? How do your calculated values of the ratios for each formant compare to each other? Any difference?)
- (continued overleaf)

(iv) 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). Explain how this fact can help explain the discrepancy between observed and predicted female:male ratios for F2 and F3. (The story on F1 is different).