

THE SCIENCE OF MUSIC

EXERCISES FOR CHAPTER 12

12.1 The overpressure in your lungs when you sing—the amount by which the lung pressure exceeds the prevailing atmospheric pressure—is about 1000 Pa.

- a) What is the velocity of the air through the vocal cords?
- b) In a typical adult the vocal cords are about 15 mm long and the opening between them averages about 0.5 mm while singing. What is the area of the opening?
- c) Based on these numbers, calculate the airflow through the vocal cords, i.e., the volume of air passed per second in m^3/s .
- d) Typical adult lung capacity is about 5 liters. Hence, calculate approximately the longest time for which a singer can hold a note.

12.2 If you sing a note with first and second formants at 700 Hz and 1500 Hz respectively, what vowel sound are you making? Where in the mouth must your tongue be to create this vowel sound?

12.3 A singer sings a note with their tongue high in their mouth and towards the back. What are the possible vowel sounds they could make if they do this, and approximately what will be the frequencies of the first two formants?

12.4 What vowel sounds is a singer producing if their first and second formants have the following frequencies?

- a) 600 Hz and 800 Hz
- b) 600 Hz and 2000 Hz
- c) 400 Hz and 2200 Hz
- d) 700 Hz and 1400 Hz

12.5 Where would the tongue have to be situated in the mouth to produce the following vowel sounds:

- a) U as in “put”
- b) A as in “spa”
- c) U as in “jump”
- d) E as in “set”

12.6 What approximately are the highest notes you could sing and still clearly make the vowel sounds:

- a) EE as in “heat”

- b) A as in “sat”
- c) Is either of these likely to be a problem in practice?

12.7 A soprano sings the note F5. List three vowel sounds that would be hard to produce clearly at this pitch.

12.8 Two different people give speeches at a microphone. One is a quiet speaker, so they turn up the volume to be heard. The other is a loud speaker, so they turn the volume down again. Assuming the actual sound level you hear is the same in both cases, which speaker will be easier to understand, and why?

12.9 A note sung strongly will contain harmonics up to about 3000 Hz, but sung quietly it may only contain harmonics up to about 1500 Hz.

- a) Explain briefly why this is.
- b) This effect can make some vowel sounds difficult to discern. List four vowel sounds that could be problematic in this way.

12.10 The speed of sound in helium is approximately 750 m/s, a little over twice that in air.

- a) If a singer breathes helium before singing, what effect, if any, will it have on the frequencies of their formants?
- b) One could get the same change in formant frequencies by having a shorter vocal cavity. If the typical vocal “pipe” is about 17 cm long, how long would it have to be to sound approximately the same as the singer breathing helium?

This is the origin of the squeaky “helium voice”—an adult who inhales helium before singing will sound roughly the same as a singer with a shorter vocal cavity, such as a child.

12.11 A singer sings a note. How will the frequency of the *note* and the frequencies of the *formants* change if:

- a) We record the singer on tape and play the recording back with the tape running at a higher speed?
- b) The singer simply sings the same vowel sound at a higher pitch?
- c) Hence explain why a sped-up tape doesn’t sound like a normal singing voice, but has a squeaky “chipmunk” sound.

12.12 What consonant would you be making if you did the following?

- a) Transitioned quickly between the vowel sounds EE and UH.
- b) Closed off your mouth, hummed through your nose, then opened your mouth.

- c) Closed off both your mouth and nose, then opened them suddenly while at the same time making a note with your vocal cords.

12.13 There are two different kinds of wobble that one can introduce into a sung note: vibrato and tremolo.

- a) What is the difference between the two?
- b) Which is commonly used in classical music performance?