

Solutions to Homework, Week 9

Assignment 1

Chapter 15

R6:

Frictive consonants: Formed by constricting air flow in the vocal tract; examples are *f*, *v*, *s*, *z*, *th*, and *sh*.

Nasal consonants: Make use of nasal cavity resonance (not often); examples are *m*, *n*, and *ng*.

Liquid consonants: Made with the tip of the tongue raised and oral cavity somewhat constricted; examples are *r* and *l*.

Semivowel: Produced by keeping vocal tract briefly in a vowel position and changing rapidly to the vowel sound that follows; examples are *w* and *y*.

Q1:

Larynx: Section of vocal tract made of cartilage that contains the vocal folds

Vocal cords: Also called vocal folds; Source of sound; Ligaments that extend across the larynx to interrupt air flow to produce sound (similar to a reed in a woodwind).

Pharynx: The tube that connects the larynx with the oral cavity; length can be changed slightly to manipulate the buzzing sound from the vocal folds

Nasal Cavity: Another cavity (tube) that can be used to produce resonance. Though not used commonly in English speaking, nasal resonance is responsible for sounds *m*, *n*, and *ng*.

Oral Cavity: A.K.A. the mouth; Very important and versatile for converting sound from vocal folds into articulate sounds and speech. The size of this resonant cavity can be changed by adjusting positions of the lips, tongue and teeth.

Tongue, Lips, and Teeth: Used to manipulate the size and shape of the oral cavity for the articulation of unique sounds.

E9: Just like calculating the frequency of air in a bottle for experiment 3 in lab, we use the equation for a Helmholtz resonator $f = \frac{v}{2\pi} \sqrt{\frac{A}{lV}}$. Here the resonator has an area of 0.6 cm^2 for the neck, a length of 3 cm, and a volume of 20 cm^3 .

I'm going to do everything in units of cm rather than convert so many quantities to meters. This means the speed of sound which is 343 m/s should be written as 34,300 cm/s.

$$f = \frac{v}{2\pi} \sqrt{\frac{A}{IV}} = \frac{34,300 \text{ cm/s}}{2\pi} \sqrt{\frac{0.6 \text{ cm}^2}{3 \text{ cm}(20 \text{ cm}^3)}} \\ = 545.9 \text{ Hz}$$

This is very close to the lowest F10 resonance of the model given as 536 Hz.

Did you remember to include units? Did you make sure it checked out with the F10 resonance that I gave for part of the problem? Did you check the back of the book to confirm the answer?

Many of you had 54 Hz or 5.4 Hz. Note that the human voice cannot make sounds as low as 54 Hz, and we cannot even hear down to 5.4 Hz.

Make sure to use common sense as well as the equation! The equation is just math; adding common sense and application gives us acoustics.

Assignment 2

Chapter 23

R6: A concert hall is considered intimate if the first reflection after the direct sound arrive before 20 ms (pg 528).

E2: Reverb time equals $T_{\text{reverb}} = 0.161 \frac{\text{Volume Room}}{\text{Area of drain}}$. We want to calculate the reverb at

500 Hz in the following concert hall: dimensions are 40 m x 20 m x 15 m (L x W x H); the side walls and ceiling are made of plaster ($\alpha = 0.06$), front and back are made of plywood ($\alpha = 0.17$); and the floor is wood ($\alpha = 0.10$); there are 1100 wooden seats that give a drain area of 0.02 m^2 per seat; and when a person is sitting in a seat, they contribute 0.17 m^2 for each person.

Note that this is a guess based on the fact that occupied upholstered seats have 0.56 m^2 and unoccupied upholstered seats have 0.39 m^2 . The difference in absorption area is probably a good guess of how much each person contributes $0.56 \text{ m}^2 - 0.39 \text{ m}^2 = 0.17 \text{ m}^2$.

So a person an occupied wooden seat gives $0.02 \text{ m}^2 + 0.17 \text{ m}^2 = 0.19 \text{ m}^2$. Because we aren't given a number in the table, we have to guess. This is just one way. However, your number for a person in wooden seat must be between 0.02 and 0.56 m^2 .

a) The volume of the room will always be the same $40\text{ m} \times 20\text{ m} \times 15\text{ m} = 12,000\text{ m}^3$. It is the drain area that changes in each of these parts. From the surfaces we get:

$$2 \text{ plywood walls} : 2(20\text{ m} \times 15\text{ m})(0.17) = 102\text{ m}^2$$

$$2 \text{ plaster side walls} : 2(40\text{ m} \times 15\text{ m})(0.06) = 72\text{ m}^2$$

$$1 \text{ plaster ceiling} : 1(40\text{ m} \times 20\text{ m})(0.06) = 48\text{ m}^2$$

$$1 \text{ wood floor} : 1(40\text{ m} \times 20\text{ m})(0.10) = 80\text{ m}^2$$

$$1,100 \text{ seats} : 1,100 \text{ seats}(0.02\text{ m}^2/\text{seat}) = 22\text{ m}^2$$

$$\text{Total drain area} = 102\text{ m}^2 + 72\text{ m}^2 + 48\text{ m}^2 + 80\text{ m}^2 + 22\text{ m}^2 = 324\text{ m}^2$$

$$T_{\text{reverb}} = 0.161 \left(\frac{\text{s}}{\text{m}} \right) \frac{12,000\text{ m}^3}{324\text{ m}^2} = 5.96\text{ s}$$

b) If the hall is half filled with people, we need to change the area of the drain since it will be bigger. The additional area of the drain will be

$$550 \text{ people} (0.17\text{ m}^2/\text{person}) = 93.5\text{ m}^2. \text{ So the total new area is}$$

$\text{Total drain area} = 324\text{ m}^2 + 93.5\text{ m}^2 = 417.5\text{ m}^2$. Therefore the new reverb time is:

$$T_{\text{reverb}} = 0.161 \left(\frac{\text{s}}{\text{m}} \right) \frac{12,000\text{ m}^3}{417.5\text{ m}^2} = 4.62\text{ s}$$

c) If the totally filled with people, we again need to change the area of the drain since it will be even bigger. The additional area of the drain will be

$$550 \text{ people} (0.17\text{ m}^2/\text{person}) = 93.5\text{ m}^2. \text{ So the total new area is}$$

$\text{Total drain area} = 417.5\text{ m}^2 + 93.5\text{ m}^2 = 511\text{ m}^2$. Therefore the new reverb time is:

$$T_{\text{reverb}} = 0.161 \left(\frac{\text{s}}{\text{m}} \right) \frac{12,000\text{ m}^3}{511\text{ m}^2} = 3.78\text{ s}$$