15.1.7: Other Acoustical Applications

The science of acoustics has been and is being applied to a large number of different problems. The following is a list of interesting applications of acoustic techniques.

Video/audio examples:

- A YouTube example where they manipulate your hearing to mimic the effect of spacial changes in the location of the source (requires headphones).
- Sound tourism; a list and samples of interesting sounds in the world by Trevor Cox.
- Interview with a blind person who uses sound to navigate.
- Putting a fire out with sound.
- Mechanical sound cancellation using acoustic metamaterial (Ghaffarivardavagh, Nikolajczyk, Anderson, and Zhang).
- In the phenomena of thermoacoustics sound is can be turned into heat or heat into sound. Using this conversion it is possible to make a thermoacoustic heat engine that acts as a heat pump or refrigerator.
- Levitation of small objects with standing sound waves. Another YouTube. Here is an article in Science about uses of sonic levitation.
- Moving Helmholtz resonators.
- Making standing wave patterns in liquids with sound. A second example with a cornstarch solution. A third example, more controlled.
- Explanation of earthquake booms, Seneca guns and other sounds.
- Discussion in *Physics Today*, vol. 71, issue 8, 2018, of infrasound as a tool for the remote sensing of thunderstorms, volcanoes, nuclear bombs and more.
- Turning scientific data into sound: Samples from a group in Germany; Wikipedia article on Sonification; Sonification of Tohoku earthquake, Japan; Sonification of particles from the sun hitting satellites; Sonification of Voyager data.
- Singing sand dunes. Here is a YouTube of booming sand.
- Here is a list of software that allows you to modify sound files to create your own acoustical effects (I have only used Audacity; I cannot vouch for the others):
    - Audacity.
    - Gold Wave.
    - Adobe Audition.
    - Praat.
    - Max and several other sound products.
    - Melodyne.
    - Fleximusic.
- Various resources on musical acoustics from the University of New South Wales.
- Dan Russell's page of simulations and animations on acoustics.

Summary

Auditorium design generally includes gently curving surfaces, diffuse reflection and controlled absorptivity of sound. Large flat surfaces with strong, specular reflection are avoided. Still, auditorium design is only partially scientific; a great deal is left to trial and error. Our perception is sensitive to reverberation, echoes, timing, intensity, phase and other clues about the direction and distance to a sound source. These effects have to be taken into account in order for a performance to sound natural, especially when electronic amplification is used.

Questions on Acoustics:

1. Define acoustics.
2. What are some of the acoustic qualities to be considered when planning a music or concert hall?
3. Who was Marcus Vitruvius Pollio and what did he do?
4. What is the principle behind Echeas?
5. Explain reverberation and how it is measured.
6. Why would you not want to get rid of reverberation entirely?
7. What does it mean if the absorptivity of absorption coefficient is zero?

8. Absorption is measured in what units?
9. If the distance to a sound source is doubled, that happens to the sound intensity?
10. What is the Comb effect and why is it useful?
11. Explain feedback (what is it, when does it occur, why does it occur).
12. What is a way to minimize echoes in a concert hall?
13. What is one of the largest factors that impact the sound of a musical performance?
14. Why do auditoriums have walls and floors that are slanted and angled?
15. In addition to reverberation our ear-brain hearing system uses four other methods to determine the direction to a sound source. Write a brief description of each.
16. What is the precedence effect?
17. How does our perception of the direction of sound from a vertical angle differ from a horizontal angle?
18. How are we fooled at a concert to think the sound we hear is coming from the singer and not from the speakers on each side?
19. A person is singing on stage, but their voice is amplified by speakers that are closer to the audience. How can you make it so the audience perceives the sound originating from the stage and not the speaker?
20. Why do speakers overhead not cause us to think the musicians are on the ceiling?
21. Is it possible to design a perfect concert hall using only scientific principles? Explain your answer.
22. Why are multiple speakers aligned in a plane going away from the stage each given a slight delay?
23. Name a famous rocker that used feedback from his guitar as part of his musical performance.
24. What two problems do standing waves pose for sound in a room?
25. How can dead spots be reduced in a room?
