

Studying Sound and Hearing

Introduction

Every day we are exposed to sounds from televisions, radios, and even traffic. Usually these sounds are present at safe volumes that do not affect our hearing. However, when exposed to sounds that are too loud or that last too long, hearing can be damaged. Conduct this simulation to understand how sound waves affect structures similar to the human ear.

Concepts

- Hearing loss
- Sensory perception

Background

The ear is an organ that serves two distinct functions—hearing and equilibrium. *Hearing* is our perception of energy carried as sound waves. *Sound waves* are alternating pressure waves with peaks of compressed air and valleys of diffuse air. *Sound* is a person's interpretation of the amplitude, frequency, and duration of the sound waves (see Figure 1).

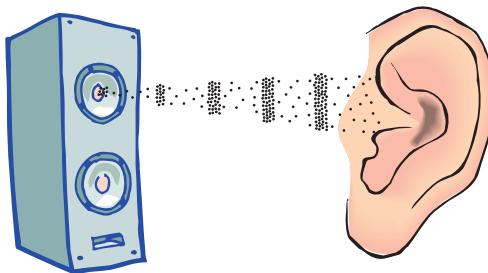


Figure 1. Sound waves consist of peaks of compressed air and valleys of diffuse air.

Sound is characterized by pitch and loudness. Pitch is interpreted as high and low sounds. Our brain interprets low-frequency waves with low-pitched sounds and high-frequency waves with high-pitched sounds. Loudness, which will be studied in this activity, is characterized by sound intensity and is also influenced by the sensitivity of an individual's ear. The intensity of a sound wave is a function of the wave *amplitude*. Intensity is measured in *decibels (dB)* (see Figure 2). Normal conversation has a noise level of around 60 dB. At concerts the music is often projected around 120 dB. This intensity places listeners in danger of damage to their hearing. The amount of damage depends on the duration and frequency of the noise.

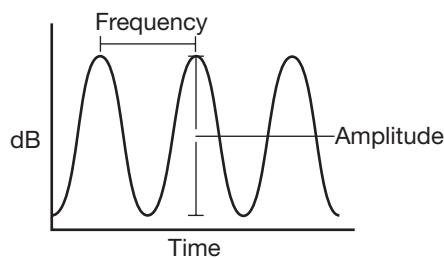


Figure 2. Sound waves are characterized by their amplitude (in dB) and their frequency (in Hz).

Electronic music players such as iPods® and other MP3 players are commonly used among teens. These electronic devices have the potential to produce noise levels that can cause damage to the ear. A recent study revealed that more than half the population of teenagers in the United States experienced ringing in their ears. *Tinnitus* is a condition characterized by the perception of ringing, buzzing, hissing, and other noises, even in the absence of sounds. It can be caused by ear infections and as a result of noise-induced hearing damage.

In order to understand how hearing loss can occur it is important to understand the anatomy of the ear. The structures of the inner ear include delicate hairs called *cilia*. Cilia bend in response to pressure waves; this movement sends signals to the brain. Cilia bend and then can break when exposed to loud sounds (classified as sounds > 80 dB) especially if the noise is extremely loud or if it occurs over an extended period of time. Once cilia break, they cannot repair themselves. Resting the ears by avoiding loud sounds for extended periods of time allow the bent cilia in the ear to recover from the pressure created by the excessive noise.

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Audiologists, professionals who diagnose and treat hearing loss, recommend limiting exposure to loud noises whenever possible. This includes turning down the volume of music players and decreasing the amount of continuous time exposed to them. Other methods of protecting hearing are earplugs, use of high-quality headphones, turning the volume down, resting ears between sessions, and not smoking. Smoking restricts blood flow; therefore the cilia are not able to recover as quickly, causing breakage.

If an audiologist suspects hearing loss, the patient is given an audiology test. In addition to a physical examination, the Weber and Rinne tests may also be performed to determine the type of hearing loss. Hearing loss is divided into two main categories—conductive and sensorineural. Conductive hearing loss occurs when sound is not conducted efficiently through the outer ear to the eardrum. It usually results in a reduction of sound level or the inability to hear quiet sounds. Sensorineural hearing loss occurs when there is damage to the inner ear or to the nerve pathways from the inner ear to the brain. This occurs as a result of being over-exposed to loud noises. Sensorineural hearing loss also involves a reduction in sound level, but also affects speech understanding, or ability to hear clearly.

Both the Weber and Rinne tests use a 512- or 1024-Hz tuning fork. During the Weber test a vibrating tuning fork is placed in the middle of the subject's forehead. The sound will seem louder in the ear with conductive hearing loss. If the sound seems to be evenly distributed between both ears it may indicate proper hearing or symmetrical hearing loss (equal loss in both ears). The Rinne test is conducted in addition to the Weber test to determine if the hearing loss is sensorineural. The vibrating tuning fork is placed directly on the mastoid process (the back side of the ear) until sound is no longer heard. Then the fork is immediately moved to the outside of the ear. Subjects with normal hearing or sensorineural hearing loss will hear the sound longer through air than through bone. If the subject has conductive hearing loss, her or she hears the sound longer through bone than air.

Materials

Sodium chloride, < 1 g

Plastic wrap

Water, tap

Rubber band

Plastic cup

Tuning fork

Safety Precautions

The chemicals used in this laboratory activity are considered non-hazardous. Wear chemical splash goggles whenever working with chemicals, heat, or glassware. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling and disposal information.

Procedure

1. Fill a plastic cup with tap water.
2. Strike the tuning fork against the rubber heel of a shoe.
3. Immediately place the tips of the tuning fork into the water.
4. Record observations on the worksheet.
5. Stretch enough plastic wrap to tightly cover the top of the cup containing water.
6. Sprinkle a small amount of sodium chloride on the top of the plastic wrap.
7. Strike the tuning fork against the rubber heel of a shoe.
8. Approach the top of the plastic wrap with the tuning fork. Observe the effect on the salt.

Weber Test

9. Strike the tuning fork against the heel of a rubber-soled shoe.
10. Hold the fork to the middle of the subject's head as shown in Figure 3.
11. Ask the subject which side the sound seems louder, if either.
12. Repeat steps 9–11 while the subject plugs his or her left ear using a finger.
13. Repeat steps 9–11 while the subject plugs his or her right ear using their finger.

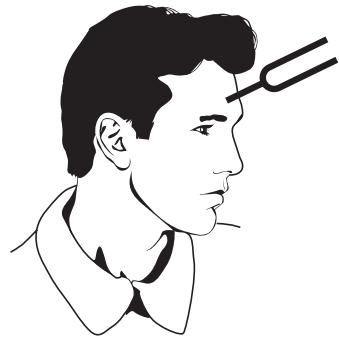


Figure 3.

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Rinne Test

14. Strike the tuning fork against the heel of a rubber-soled shoe.
15. Hold the tuning fork against the bone behind of the subject's right ear as shown in Figure 4.
16. Have the subject count how many seconds he or she hears the sound.
17. Repeat step 14 and hold the fork near the right ear as shown in Figure 5.
18. Have the subject count how many seconds he or she hears the sound.

Note which form of conduction lasted longer.



Figure 4.

Figure 5.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. All materials may be disposed of by Flinn Suggested Disposal Method #26a or saved for future use.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12

Evidence, models, and explanation
Evolution and equilibrium

Content Standards: Grades 5–8

Content Standard C: Life Science, structure and function in living systems
Content Standard F: Science in Personal and Social Perspectives, personal health

Content Standards: Grades 9–12

Content Standard C: Life Science, matter, energy, and organization in living systems
Content Standard F: Science in Personal and Social Perspectives, personal and community health

Tips

- This activity is available from Flinn Scientific as a student laboratory kit, *Understanding Sound and Hearing* (Catalog No. FB1994).
- This laboratory experiment should not be used as a diagnostic tool. If hearing loss is suspected, please seek professional testing from an audiologist.

References

McDonough, J. T.; Matkins, J. J. Using Sound Knowledge to Teach About Noise-Induced Hearing Loss. *Science Scope*. 2007, p 42–47.

Silverthorn, D. *Human Physiology: An Integrated Approach*; Pearson: Benjamin Cummings: San Francisco, CA; 2004; pp 341–342.
American Speech-Language-Hearing Association. Type, Degree and Configuration of Hearing Loss. <http://www.asha.org/public/hearing/disorders/types.htm> (Accessed December 2010).

Materials for *Studying Sound and Hearing* are available from Flinn Scientific, Inc.

Catalog No.	Description
FB1994	Understanding Sound and Hearing—Student Laboratory Kit
AP6984	Tuning Forks, Set of 4, Economy Choice

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices