



*Drexel-SDP GK-12 ACTIVITY*

## Activity Template

**Subject Area(s):** Sound

**Associated Unit:** None

**Associated Lesson:** None

**Activity Title:** How good is your hearing?

**Grade Level:** 8 (7-9)

**Activity Dependency:** None

**Time Required:** 120 minutes

**Group Size:** 3-4 students

**Expendable Cost per Group:** US \$0.00

### **Summary:**

In this activity, students will learn about the frequency range of human hearing, data collection procedures, mean, median, mode, range and plotting of tabulated results. This activity also makes an attempt to explain the observable differences in human hearing amongst people of various ages while discussing the physical characteristics of the ear that allow humans to hear. As a result of this activity, students will understand how to collaborate with other people to perform an experiment in search of a strongly supported conclusion.

### **Engineering Connection:**

Audio engineers are constantly developing better performing audio recording equipment, audio data compression algorithms and higher quality playback devices without knowledge of human hearing, however the engineers may be wasting data collection and storage on frequency ranges that human is unable to hear. Therefore, after many

psychoacoustic experiments and evaluations audio engineers can take into account that human hearing is generally specified to range from 20Hz to 20kHz. This knowledge enables engineers to make equipment that only record in certain frequency ranges, which saves data storage space and allows for faster transmission of the audio to another location. Overall, audio engineering needs the expertise of psychoacoustic researchers to produce quality and efficient products that can reproduce high quality audio.

**Keywords:** mean, median, mode, range, box-and-whisker plot, stem-and-leaf plot

### **Educational Standards**

Science: None

Math: 2.6 Statistics and Data Analysis

### **Learning Objectives**

After this lesson, students should be able to:

- Calculate mean, median, mode and range of a set of data
- Explain what affects a person's audible frequency hearing range
- Create box-and-whisker plots
- Create stem-and-leaf plots
- Create a bar graph

### **Materials List**

Each group needs:

- computers
- headphones
- worksheet
- pen or pencil
- internet connection

### **Introduction / Motivation**

The development of audio equipment is based on the characteristics of the ear, including both the physical shape and the psychoacoustic nature of the ear. Therefore, the study of the capabilities and limitations of the ear is extremely important in the production of high quality audio products that range from audio recording equipment to hearing aids.

Without this type of research people who are partially deaf would not have the chance to hear any sounds at all. The ear is a delicate, but powerful sensory organ that allows humans to avoid danger, communicate and enjoy the sounds of the world.

### **Vocabulary / Definitions**

Word	Definition
mean	the sum of all the numbers in the set divided by the number of numbers in

	the set
median	the number that divides the ordered set in half, if there are two middle numbers then both of them are the median
mode	the number or numbers with the highest number of occurrences
range	the difference between the greatest and smallest numbers in the set of numbers

## **Procedure**

### **Background**

The ear is a powerful sensory organ that allows humans to detect sound through vibrations in the air, water or other matter. The vibrations are energy in the form of waves of pressure that are collected by the outer ear and then funneled into the middle ear. In this part of the ear, the pressure changes are amplified before reaching the inner ear. The sound then passes through the inner ear as hair cells convert the changes in air pressure to a signal of nerve pulses. Then, the pulses are sent through the nerves to the brain where humans acknowledge the sound perceived. Although the ear is generally thought to be used for hearing only, that is not true. The ear is a major component in body balance and position that is often associated with the term equilibrium. For example, when people get sick on roller coasters it is because their equilibrium is not correct, which yields a sense of imbalance and sickness. Some people are more susceptible to this feeling of not having equilibrium in their ears. Therefore, the ear is both important for hearing, balance and awareness of body position.

### **Before the Activity**

- Make sure each computer has access to the internet and that the website works on each computer
- Print out both the recording and results worksheets for each

### **With the Students**

1. Go through an example of how to use the interface
2. Make sure that the students understand that they are in groups, but must record data individually
3. Have the students plug the headphones into the computer for this exercise and make sure the computer volume is adjusted properly
4. The students should open the Hearing Test High Interface to begin the process of testing for the highest frequency they can hear (This is located at <http://schubert.ece.drexel.edu/gk12> under the Activities category)
5. The students will use the Frequency Selection Bar to select different frequencies that they will hear over the headphones and see the waves that appear in white box
6. The students will use the Amplitude Adjustment Slider to change the amplitude of the sound waves they hear over the headphones and see the waves that appear in the white box on the right
7. Have the students click the Play button to play the sound specified by the frequency and amplitude selected (Note: To stop playing the sound click the Stop button)

8. Have the students briefly experiment with both the Frequency Selection Bar and the Amplitude Adjustment Slider.
9. Have the students record the effect the Frequency Section Bar has on both the sound they hear and the wave generated in the white box in the *Observations* section of the worksheet
10. Have the students record the effect the Amplitude Adjustment Slider has on both the sound they hear and the wave generated in the white box in the *Observations* section.
11. When the students are familiar with how this interface functions, they should determine which frequencies in the Frequency Selection Bar they can hear and record the results in the *Observations* section
12. Have students test the lowest frequency they can hear by navigating to the Hearing Test Low Interface (This is located at <http://schubert.ece.drexel.edu/gk12> under the Activities category)
13. Repeat steps 10 and 11 for this interface
14. Close the browser
15. Have the students report their frequency observations to you

### **Attachments**

- [Frequency Hearing Testing](#)
- [Frequency Hearing Results](#)

### **Safety Issues**

- No safety issues

### **Investigating Questions**

- Why do younger people generally have better hearing than older people?
- What is the difference between volume and pitch?

### **Assessment**

#### **Pre-Activity Assessment**

*Class Discussion:*

- Talk with the students how different animals have different frequency hearing ranges (i.e. dog's respond to dog whistle)
- Talk about how loudness and frequency are different and that students should be listening for frequency and not loudness

#### **Activity Embedded Assessment**

*Group Participation:* Mark down who reports their hearing test results to you

*Lab handout/worksheet:* Collect the second worksheet after the students have completed it so that you can measure concept comprehension by grading the worksheet

#### **Post-Activity Assessment**

*Lab Report:* Have the students write a detailed lab report in a formal manner. The report should begin by with stating the problem and the predicted hypothesis of the student with reasoning. In the problem section the question would be “What is the highest and lowest frequency that you can hear?” The hypothesis would be, “If I listen to a range of frequencies using headphones and a computer I believe that I will be able to hear \_\_\_\_\_ as my lowest frequency and \_\_\_\_\_ as my highest frequency.” Then the materials and procedure sections should follow the worksheet handed out to the students, with the students adding details to the procedure in the lab handout when needed. The observations will be written informally on the handout, but should be rewritten on the lab report. The results section is a restatement of the observations with analysis of the data. Last is the conclusion paragraph, which states whether the hypothesis was correct or not and why. This formally written report will judge overall comprehension of the activity.

### **Activity Extensions**

- The students can test family members’ and other friends’ hearing
- The students can research the frequency hearing ranges of different animals

### **Activity Scaling**

- For lower grades, the activity should be able to stay mostly the same as long as the students can perform addition and division
- For upper grades, the activity could stay exactly the same, but with more detail about the reasoning behind the differences in lowest and highest frequency hearing by the students. Also, a more detailed discussion about the inner ear would strengthen a better overall understanding

**Owner:** Drexel University GK-12 Program

**Contributors:** Travis M. Doll, ECE Department, Drexel University

**Copyright:** Copyright 2008 Drexel University GK12 Program. Reproduction permission is granted for non-profit educational use.

## Frequency Hearing Testing

Names: \_\_\_\_\_

### Materials

---

- Headphones
- Computer

### Lab Instructions

---

1. Plug the headphones into the computer for this exercise and make sure the computer volume is adjusted properly (Adjust the volume as needed throughout the lab)
2. Open the Hearing Test High Interface to begin the process of testing for the highest frequency you can hear (This is located at <http://schubert.ece.drexel.edu/gk12> under the Activities category)
3. The Frequency Selection Bar will be used to select different frequencies that you will hear over the headphones and see in the waves that appear in white box
4. The Amplitude Adjustment Slider will be used to change the amplitude of the sound waves you hear over the headphones and see in the waves that appear in the white box
5. The Play button is used to play the sound specified by the frequency and amplitude selected (Note: To stop playing the sound click the Stop button)
6. Briefly experiment with both the Frequency Selection Bar and the Amplitude Adjustment Slider.
7. Determine the affect the Frequency Section Bar has on both the sound you hear and the wave generated in the white box and record this data in the *Observations* section
8. Determine the affect the Amplitude Adjustment Slider has on both the sound you hear and the wave generated in the white box and record this data in the *Observations* section.
9. Now that you are familiar with how this interface functions, determine which frequencies in the Frequency Selection Bar you can hear
10. Do this by selecting each frequency and listening through the headphones to determine if you can hear the pitch produced (Note: If you feel like you can't hear a pitch, it may be that the volume is too low or try adjusting the Amplitude Adjustment Slider and the computer's volume)
11. Record your findings in the *Observations* section.
12. Now test the lowest frequency they can hear by navigating to the Hearing Test Low Interface (This is located at <http://schubert.ece.drexel.edu/gk12> under the Activities category)
13. Repeat steps 10 and 11 for this interface
14. Again, record your findings in the *Observations* section
15. Close the browser
16. Report your frequency observations to the teacher.

## Observations

---

What affect does the Frequency Selection Bar have on the displayed wave in the white box?

What affect does the Frequency Selection Bar have on the sound heard through the headphones?

In the boxes below draw a sound wave with a high frequency in the box on the left and a sound wave with a low frequency in the box on the right. Label the axes.



high frequency



low frequency

What affect does the Amplitude Adjustment Slider have on the displayed wave in the white box?

What affect does the Amplitude Adjustment Slider have on the sound heard through the headphones?

In the boxes below draw a sound wave with high amplitude in the box on the left and a sound wave with low amplitude in the box on the right. Label the axes.



high amplitude



low amplitude

Hearing Test for Highest Frequency (place a check next to the frequencies you can hear for each member in the group):

- |                                   |                                   |                                   |
|-----------------------------------|-----------------------------------|-----------------------------------|
| <input type="checkbox"/> 15500 Hz | <input type="checkbox"/> 17000 Hz | <input type="checkbox"/> 18500 Hz |
| <input type="checkbox"/> 16000 Hz | <input type="checkbox"/> 17500 Hz | <input type="checkbox"/> 19000 Hz |
| <input type="checkbox"/> 16500 Hz | <input type="checkbox"/> 18000 Hz |                                   |

Hearing Test for Lowest Frequency (place a check next to the frequencies you can hear for each member in the group):

- |                                |                                |                                |
|--------------------------------|--------------------------------|--------------------------------|
| <input type="checkbox"/> 5 Hz  | <input type="checkbox"/> 20 Hz | <input type="checkbox"/> 35 Hz |
| <input type="checkbox"/> 10 Hz | <input type="checkbox"/> 25 Hz | <input type="checkbox"/> 40 Hz |
| <input type="checkbox"/> 15 Hz | <input type="checkbox"/> 30 Hz |                                |

**Results**

Highest Frequency Each Member Can Hear: \_\_\_\_\_

Lowest Frequency Each Member Can Hear: \_\_\_\_\_

Note: Remember to report your findings to the teacher.

## Frequency Hearing Results

Collected Data from \_\_\_\_\_ Students

---

### Lowest Frequency Heard Class Data

_____ 5 Hz	_____ 20 Hz	_____ 35 Hz
_____ 10 Hz	_____ 25 Hz	_____ 40 Hz
_____ 15 Hz	_____ 30 Hz	

### Highest Frequency Heard Class Data

_____ 15500 Hz	_____ 17000 Hz	_____ 18500 Hz
_____ 16000 Hz	_____ 17500 Hz	_____ 19000 Hz
_____ 16500 Hz	_____ 18000 Hz	

### Calculations

---

1. Find the mean, median, mode(s) and range of the lowest frequency data in the Collected Data section. Show your work and make sure to **include the units in the answer!**

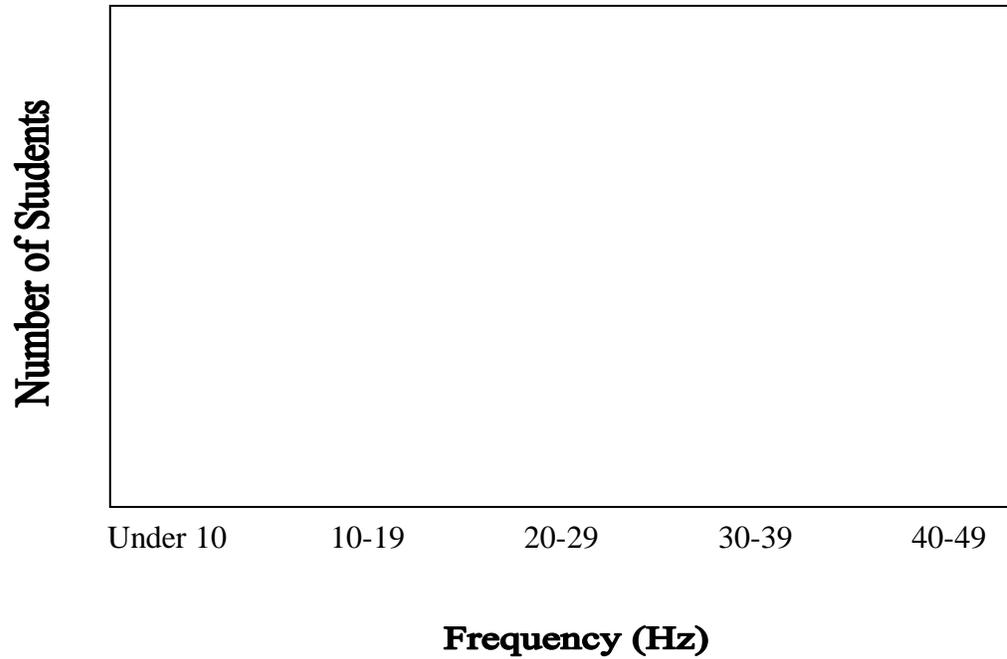
mean \_\_\_\_\_ median \_\_\_\_\_ mode(s) \_\_\_\_\_ range \_\_\_\_\_

2. Find the mean, median, mode(s) and range of the highest frequency data in the Collected Data section. Show your work and make sure to **include the units in the answer!**

mean \_\_\_\_\_ median \_\_\_\_\_ mode(s) \_\_\_\_\_ range \_\_\_\_\_

3. Create a bar graph of the number of students that heard the following frequencies as their lowest frequency value:

5, 35, 25, 15, 20, 15, 15, 10, 15, 20, 15, 25, 10  
15, 5, 20, 25, 15, 15, 25, 20, 5, 15, 20, 15, 5



4. Create a box and whisker plots from the data in Lowest Frequency Heard Class Data on page 1.



5. Create a stem and leaf plot for the following data:

57, 49, 35, 32, 33, 26, 36, 36, 29, 51, 37, 28,  
57, 54, 42, 40, 21, 26, 34, 22, 20, 19, 22, 32, 14

Stems	Leaves

6. Determine the percentage of students that heard each frequency for each of the frequencies below.

5, 35, 25, 15, 20, 15, 30, 10, 15, 20, 15, 25  
15, 5, 20, 25, 15, 30, 25, 20, 5, 15, 20, 15, 5

% that heard 5 Hz = \_\_\_\_\_

% that heard 25 Hz = \_\_\_\_\_

% that heard 10 Hz = \_\_\_\_\_

% that heard 30 Hz = \_\_\_\_\_

% that heard 15 Hz = \_\_\_\_\_

% that heard 35 Hz = \_\_\_\_\_

% that heard 20 Hz = \_\_\_\_\_