

Name: _____ Date: _____

Student Exploration: Hearing: Frequency and Volume

[Note to teachers and students: This Gizmo involves listening to and comparing faint sounds. It is recommended that students use headphones and that the room is kept as quiet as possible.]

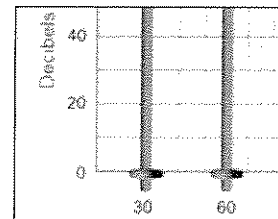
Vocabulary: decibel, equal-loudness curve, frequency, hertz, logarithm, pitch, threshold, volume

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. A dog whistle emits a sound that dogs can hear but humans cannot. Why do you think dogs can perceive this sound? _____
2. How do you think your ability to perceive different sounds might change as you age?

Gizmo Warm-up

Have you ever wondered how good your hearing is? The *Hearing: Frequency and Volume* Gizmo™ allows you to test how well you hear tones at different **frequencies**. The frequency of a sound wave is measured in **hertz** (Hz), where 1 Hz is equal to one wave passing each second. Frequency is related to the **pitch** of a sound, or whether it sounds high (like a whistle) or low (like a tuba).



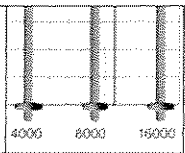
Before you begin, be sure you are in a very quiet setting. Headphones are recommended for this Gizmo. Set the **System volume** to 1 and click the **test** button (🔊). Adjust the **System volume** and your computer so that you hear a moderately loud tone when you click **test**.

1. Drag the **60-Hz** slider and the **4,000-Hz** slider to the top and click **Play** for each sound.

Describe what you hear. _____

2. In general, how does the frequency of a sound relate to its pitch? _____



Activity A: Create an equal-loudness curve	Get the Gizmo ready: <ul style="list-style-type: none"> Return all sliders to their minimum values. Turn on Show logarithmic grid and Show decibel values. 	
--	---	---

Introduction: The **volume**, or intensity, of a tone is measured in a unit called the **decibel** (dB). Decibels are the base-10 **logarithm** of the ratio of one volume to another. A 10-dB tone is 10 times more powerful than a 0-dB tone. A 20-dB tone is 10 times more powerful than a 10-dB tone and 100 times more powerful than a 0-dB tone.

Question: How well do you hear sounds of different frequencies?

- Calibrate: Set the **1,000-Hz** slider to 10 dB and click **PLAY**. If you can't hear anything, raise the **System volume** or increase your computer's volume until the tone is barely perceptible.
- Observe: Move all of the sliders to 50 dB. Click **Play full sequence (20 sec)**. What do you notice about the perceived volumes of the tones? _____

- Predict: Do you think humans hear low-frequency, medium-frequency, or high-frequency tones the best? Explain why you think so. _____

- Compare: Play the 1,000-Hz tone and the 125-Hz tone. Both of these tones have the same volume in decibels. Which tone appears to be louder to you? _____
- Measure: Adjust the **125-Hz** slider until the 125-Hz tone appears to be just as loud as the 1,000-Hz tone. At what decibel level is this the case? _____
- Gather data: Repeat this procedure for each of the other tones in the Gizmo. Now when you click **Play the full sequence**, each tone should sound equally loud. Record the decibel level of each tone below (all frequencies in Hz):

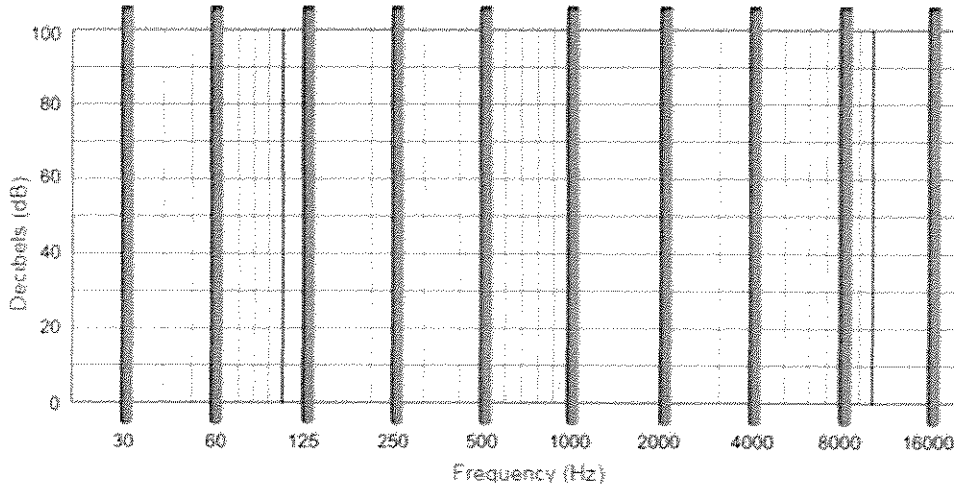
30	60	125	250	500	1,000	2,000	4,000	8,000	16,000

(Activity A continued on next page)



Activity A (continued from previous page)

7. Make a graph: Draw dots to mark the position of each slider on the graph below. Connect the dots to create an equal-loudness curve.







8. Analyze: What does this equal-loudness curve show? _____

9. Think and discuss: How do you think your equal-loudness curve will change as you age?

10. Experiment: If possible, have your teacher or another adult produce an equal-loudness curve. How does their curve compare to yours, and how did this compare to your prediction?



Activity B: Thresholds of perception	Get the Gizmo ready:	PLAY 	PLAY 
	<ul style="list-style-type: none"> Return all sliders to their minimum values. Check that the sound levels are still calibrated (see procedure at the start of activity A). 		

Introduction: A **threshold** is a minimum amount of a stimulus, such as sound, that can be perceived. In this activity, you will measure your sound thresholds at different frequencies.

Question: What are the faintest sounds that you can perceive?

1. Predict: How do you think the equal-loudness curve you will create in this activity will compare to the equal-loudness curve you made in activity A? _____

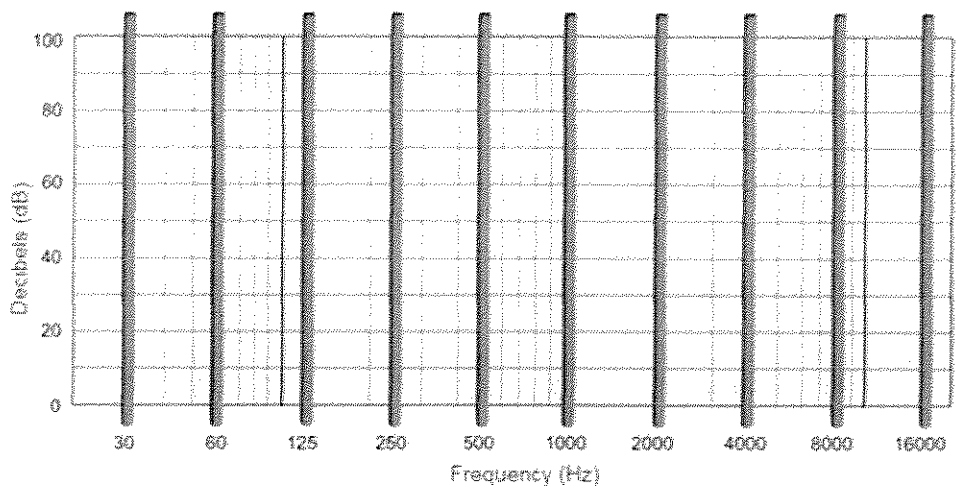
2. Measure: Play the 1,000-Hz tone at 20 dB. Then decrease the decibels slightly and play the sound again. Adjust the decibels until you have found the faintest sound that you can hear.

What is the lowest volume that you can still hear the 1,000-Hz tone? _____

3. Gather data: Repeat this procedure for each of the other tones in the Gizmo. Record the minimum decibel level that you can perceive for each tone below (all frequencies in Hz):

30	60	125	250	500	1,000	2,000	4,000	8,000	16,000

4. Make a graph: Draw the resulting equal-loudness curve on the graph below.



(Activity B continued on next page)