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# Powers of Sound

**H**ave your parents ever asked you to turn the volume of your stereo down? You don't think it's too loud, so why do they? We each have our own internal "loudness meter" that tells us the volume we are comfortable with. What's just right for you may be deafening to someone else—or is it?

For an objective opinion, you can turn to a sound-level meter, which measures the intensity, or loudness, of sounds. Sound intensity is the amount of energy in sound and is measured in decibels (dB).



The base unit for measuring sound is the bel—one decibel equals 0.1 bel. The decibel scale has an important difference from most scales used to measure things, however. On many scales, such as temperature or speed, the increments represent added differences; for example, a temperature of 50° is 10° more than 40°. The difference between 50 and 40 decibels, though, is ten *times* more. That's because the decibel scale is logarithmic, and the increases are exponential. Since you already know what exponents and powers are, this idea isn't as hard to grasp as you might think.

First, you need to understand that a logarithm is the exponent you use to raise a given number to a power. When you look for the logarithm, or log, of a number, you identify the exponent you used to raise a base to a power. Consider what you know about exponential functions.

$$\begin{array}{ccc} \text{power} & = & \text{base}^{\text{exponent}} \\ \uparrow & & \uparrow \uparrow \\ 100 & = & 10^2 \end{array}$$

This same number can be written in an inverse, or logarithmic, form using this format:

$$\begin{array}{ccc} \text{exponent} & = & \log_{\text{base}} \text{power} \\ \uparrow & & \uparrow \uparrow \\ 2 & = & \log_{10} 100 \end{array}$$

Since we ordinarily work in base 10, the base is understood—it doesn't need to be written. Base 10 is called the common logarithm.

$$2 = \log 100$$

$$3 = \log 1,000$$

$$12 = \log 1,000,000,000,000$$

Since each decibel is 10 times the common logarithm of the power, multiply the logarithm by 10. Think:  $2 = \log 100$ , so  $10 \times 2 = 10 \times \log 100$ .

$$20 = 10 \log 100$$

$$30 = 10 \log 1,000$$

$$120 = 10 \log 1,000,000,000,000$$

Because the decibel scale is logarithmic, each increase in 10 dB means a tenfold increase in loudness. A sound you can just barely hear is 1 dB, and someone whispering is about 20 dB. The whisper is not 20 times louder than the sound you just barely heard—it's 100 times louder. At 120 dB, a rock concert is a *billion* times louder than that slight sound you heard.

Sound	Decibels (dB)	Exponential Increase	
hearing threshold	0	$10^0 = 1$	
	10	$10^1 = 10$	
	whisper at 1 m	20	$10^2 = 100$
		30	$10^3 = 1,000$
		40	$10^4 = 10,000$
normal speech	50	$10^5 = 100,000$	
	60	$10^6 = 1,000,000$	
	70	$10^7 = 10,000,000$	
	80	$10^8 = 100,000,000$	
power tools	90	$10^9 = 1,000,000,000$	
	100	$10^{10} = 10,000,000,000$	
earphones on high	110	$10^{11} = 100,000,000,000$	
rock concert	120	$10^{12} = 1,000,000,000,000$	

Sound at about 120 dB causes pain, but hearing loss can begin at much lower thresholds if you listen to the sound for a long enough time. Part of the reason noise may seem louder to your parents than to you may be that you have already lost some of your hearing. So play it safe; lower the volume on your earphones and wear earplugs to rock concerts. Hearing isn't everything, but you sure don't want to lose what you've got left.



**Put an X in the square beside the best answer.**

1. The sound level of a normal conversation with your friends would be about \_\_\_\_\_.  
 10 decibels                       30 decibels                       60 decibels                       100 decibels
2. The main idea of the last paragraph in the article is that \_\_\_\_\_.  
 rock concerts are too loud                       you may already have lost some of your hearing  
 you should wear earplugs all the time                       you can damage your hearing if you are not careful
3. If your job requires you to use power tools all day long, then you \_\_\_\_\_.  
 are already accustomed to loud noises  
 should speak a little louder than normal  
 should wear earplugs to protect your hearing  
 don't need earplugs because the loudness is less than 120 decibels
4. To rewrite an exponential function as a logarithm, *first* write the \_\_\_\_\_.  
 power                       base                       exponent                       log
5. Which of these statements is an opinion?  
 Some people are comfortable with very loud volumes.  
 A rock concert is loud enough to damage hearing.  
 The decibel scale measures sound intensity logarithmically.  
 A 40-db sound is ten times louder than a 30-dB sound.
6. In paragraph 2, the word meter means \_\_\_\_\_.  
 a measurement stick                       a measurement equal to 100 centimeters  
 volume control                       an instrument for measuring something



**Write your answer to the following question on the lines below.**

Name some examples of noise pollution. Discuss why noise pollution in our society is or is not something we should be concerned about.

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