



Sound Measures

Students use a sound level meter to measure, compare and graph sound levels in different environments.

SCIENCE TOPICS

Sound Waves
Vibrations
Sound
Sense of Hearing
Health
Energy

PROCESS SKILLS

Observing
Controlling Variables
Inferring
Questioning
Hypothesizing
Collecting Data & Graphing
Analyzing Data
Health skills
Scientific Inquiry

GRADE LEVEL

5 - 9

TIME REQUIRED

Advance Preparation

30 minutes

Set-Up

15 minutes

Activity

30 minutes

Clean-Up

5 minutes

MATERIALS

- Sound level meter *
- Blender or radio
- Meter stick or tape measure

* hand-held digital sound level meters can be purchased at Radio Shack

ADVANCE PREPARATIONS

- Become familiar with the operation of the sound level meter.
- Acquire a blender or radio to produce the sound. A blender is recommended.

INTRODUCING THE ACTIVITY

Introduce the decibel chart – See page 38 and Appendix B. zero decibels represents the softest sound we can hear, the threshold of hearing. An increase of 6 decibels represents a doubling of the air pressure change created by the sound wave. A 30 decibel increase creates 32 times as much sound pressure as did the original sound. In other words, a 40 decibel sound creates sound pressure levels that are more than 30 times as great as a 10 decibel sound. The threshold of pain for the average human ear is 120 decibels. **This represents a pressure change over 991,000 times greater than that experienced by the ear when exposed to a 0 decibel sound!**

Ask students to make hypotheses about what happens to a sound as you get further and further away from the source or closer to the source. Does the sound get louder or softer? How fast does the sound change?

CLASSROOM ACTIVITY

Procedure:

- Place blender or radio near the edge of a flat surface facing the classroom. If using a radio, turn on the radio and de-tune near a known radio station until there is a constant static sound. If using a blender, turn it onto the loudest setting.
- Set the sound level meter to 80 dB, select setting **A** for **Weighting** and set the **Response** setting to **SLOW**.
- Have a student hold the sound level meter about 4 inches away from the radio or blender.
- Adjust the speed of the blender or volume of the radio to get as close to a steady 80 dB reading as possible. This will be the initial sound level and the zero distance for comparing sound levels change with distance.

- Without changing the speed of blender or volume on the radio, have the student move away about 4 or 5 steps from the sound source holding the sound level meter and record the sound level in dB. You may need to reduce the decibel range of the sound level meter as it is moved further away from the source of the sound.
- Have the student move back another 10 steps holding the sound level meter and record sound levels in dB.
- Collected data can be graphed with distance as the independent variable (x-axis) and sound level as the dependent variable (y-axis).
- Procedure may be repeated with the weighting adjustment selected for C-weighting.
- Note: the results will vary depending on the acoustic characteristics of the room.

DISCUSSION

Ask students the questions in bold. *Possible responses are in italics.*

Ask students if the sound level changed with distance as they had predicted. Was the change faster or slower than they thought it might be?

Answers will vary with predictions.

Ask students to give examples of some loud sounds they are exposed to in their environment.

Noise is not the only cause of hearing loss, but it is the most common cause in America (and in other industrialized nations). Loud sounds (above 85 dB for 8 or more hours) can hurt your ears by damaging the sensitive hair cells of the inner ear. It makes no difference whether you like the loud sounds or not – if they are over 85 dB, they can begin to damage hair cells in your inner ear.

Because there is currently no treatment to repair hair cells that have been damaged by loud sound, it is important for people to protect themselves from such damage. Fortunately, there are several actions a person can take to prevent noise-induced hearing loss.

Following are three major ways to obtain hearing protection.

- Turn down the volume
- Walk away (put as much distance as possible between your ears and the sound source)
- Wear hearing protection

QUESTIONS TO DETERMINE WHETHER YOU ARE BEING EXPOSED TO EXCESSIVE SOUND THAT MAY DAMAGE YOUR HEARING:

- Are you often in an environment where the sound is so loud that you have to shout to make yourself understood?
- After exposure to loud sound, have you ever noticed tinnitus (ringing or other noises in your ears or head)?
- Does music sound slightly strange or distorted after you have been listening for a while?
- Do voices sound muffled after you've been around loud music or other loud sounds for an extended time?
- After exposure to loud sound, do your ears sometimes feel “full” or “stopped up”?
- When you are listening to stereo headphones or a personal music player, can a person standing next to you hear it too? (When you are using a personal music player, you should be able to understand a person next to you speaking in a normal tone of voice.)

If you answer YES to any of these questions, you may have been exposed to damaging sound levels.

EXPLANATION

In-depth background information for teachers and interested students.

The ability of a normal, healthy human ear to hear spans an enormous range. Because of this, the scale for measuring sound must also span an enormous range yet still be easy and compact to write. This is why the **decibel** scale is related logarithmically to the huge range of **pressure amplitudes** that the ear is subjected to. This helps us to compress the huge range of hearing so that our response to variations in loud sounds is similar to the response to variations in weak sounds. The pressure change experienced by the ear when subjected to a 120 decibel sound (**Caution! This is the pain threshold for the average human ear!**) is about one million times greater than the pressure change

created by the softest sound we can hear, defined as 0 decibels. It is easier and takes less room to write 0 dB or 120 dB than a number followed by six zeroes!

To understand the relation between pressure amplitude and decibels it helps to understand that as a sound wave moves through the air, slight increases and decreases of the background air pressure occur. The size of these increases and decreases are called **pressure amplitude**. The size of these increases and decreases is also related to the loudness of the sound.

Decibel scales can be used for many measurements other than sound where there are large ranges of values. There are decibel scales defined for use in electronics and optics. The scales vary depending on what quantity is being used as a reference. One of the decibel scales for sound provides a way of creating a logarithmic scale **relative** to a pressure amplitude reference. This reference value is referred to as the **threshold of hearing** (for obvious reasons).

The pressure amplitude for the threshold of hearing is:

$$2 \times 10^{-5} \text{ N/m}^2$$

This is a standard value defined for a pure sine wave at a frequency of 1000 Hz. The decibel scale for pressure amplitude is called **Sound Pressure Level**, typically abbreviated **SPL**. The formula relating SPL to pressure amplitudes is:

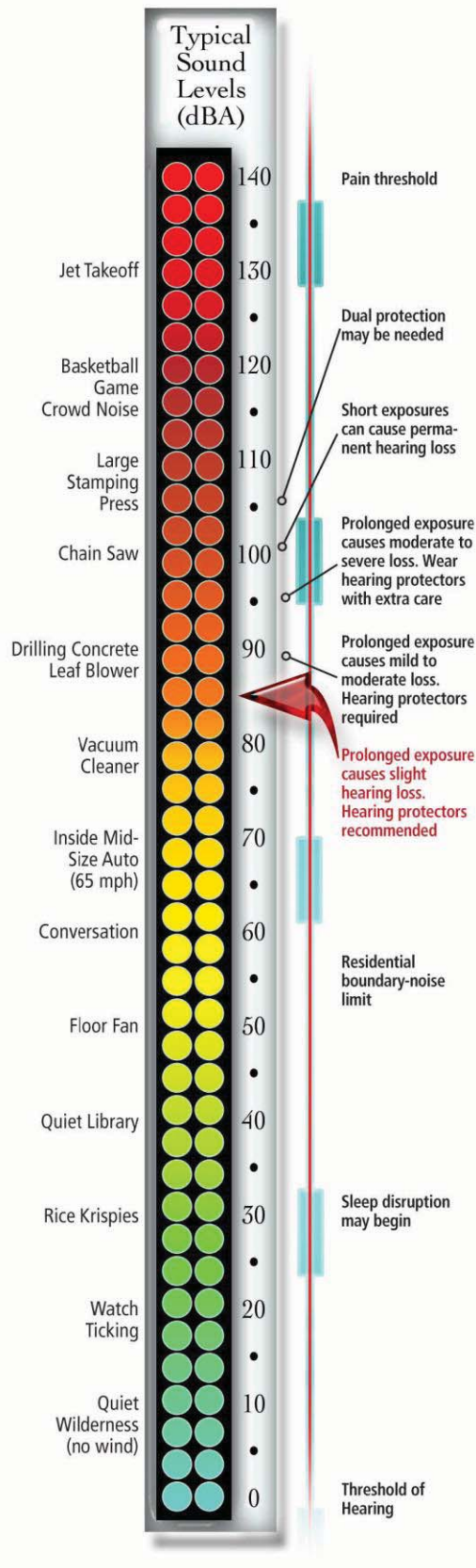
$$\text{SPL} = 20 \log(P/P_0)$$

Where: **SPL** is the sound pressure level in decibels

P₀ is the reference threshold of hearing, $2 \times 10^{-5} \text{ N/m}^2$

P is the measured pressure amplitude in N/m^2

Using this formula, it can be shown that an increase of 6 decibels results in a doubling of the pressure amplitude (and a decrease of 6 dB cuts the pressure amplitude in half). Or that increasing the SPL from 70 dB to 80 dB increases the pressure amplitude experienced by the ear by 3.16 times and increasing from 70 dB to 90 dB increases pressure amplitude by $(3.16)^2$ or about 10 times.



How Loud Is It?

The graphic on this page was developed by Elliott Berger, MS, Senior Scientist with 3M Occupational Health and Environmental Safety Division.

It is available as a free download at http://www.e-a-r.com/hearingconservation/faq_main.cfm. This list of information sheets might be helpful to teachers and students. #1 on the list is this graphic. #2 is an excellent Excel file listing 1,700 sounds with a decibel rating on each.

OPTIONAL EXTENSIONS

- Allow students to use sound level meter to monitor sound levels during activities around the school such as lunch room, pep rally, classroom, test time, playground, etc.
- Allow students to check out sound level meters and monitor at-home activities such as street, interior auto, and music listening sound levels.