Experiment P-26
Exploring Sound

Physics

Objectives

- To learn how to measure different intensities of sound.
- To understand the meaning of sound units (dB).
- To get a feeling of what dangerous high intensities of sound mean.

Modules and Sensors

- PC + NeuLog application
- USB-200 module
- BAT-200 Battery module (optional)
- NUL-212 Sound logger sensor

Equipment and Accessories

▪ Audio device (or other steady sound source)
▪ Recorder (musical instrument)

- The recorder is included in the NeuLog Sound kit, SND-KIT.

- The recorder and audio device could be replaced by other sound sources and musical instruments.

Introduction

Sound is a travelling wave that is an oscillation of pressure transmitted through a solid, liquid, or gas. It is composed of frequencies within the range of hearing and of a level sufficiently strong to be heard (the American heritage dictionary of the English language).

Sound intensity is defined as the sound power per unit area. Usually it refers to the measurement of sound intensity in the air at a listener's location. The basic units are watts/m^2 or watts/cm^2. Sound intensity measurements are made relative to the standard threshold of human hearing intensity at 1000 Hz, I_0 :

$$I_0 = \frac{10^{-12}\, watts}{m^2} = \frac{10^{-16}\, watts}{cm^2}$$

The decibel scale is the most common way to measure sound intensity. Decibels measure the ratio of a given intensity I to the threshold of hearing intensity, I_0 .

$$I(dB) = 10log_{10}[I/I_0]$$

When I=I_0 the sound level is 0 dB. A given intensity which is 10,000 times the threshold produces 40 dB $(10log_{10}[10{,}000] = 40)$.

The following table shows some typical sound levels in dB.

Sounds	**dB**
Rocket Launching	180
Jet Engine	140
Thunderclap, Air Raid Siren (1 meter)	130
Jet takeoff (200 ft)	120
Rock Concert, Discotheque	110
Firecrackers, Subway Train	100
Heavy Truck (15 Meter), City Traffic	90
Alarm Clock (1 Meter), Hair Dryer	80
Noisy Restaurant, Business Office	70
Air Conditioning Unit, Conversational Speech	60
Light Traffic (50 Meter), Average Home	50
Living Room, Quiet Office	40
Library, Soft Whisper (5 Meter)	30
Broadcasting Studio, Rustling Leaves	20
Hearing Threshold	0

The human ear can respond to minute pressure variations in the air if they are in the audible frequency range, roughly 20 Hz - 20 kHz. It can detect pressure variations of less than one billionth of atmospheric pressure. This incredible sensitivity is enhanced by an effective amplification of the sound signal by our ear structure. There are also protective mechanisms that reduce the ear's response to very loud sounds.

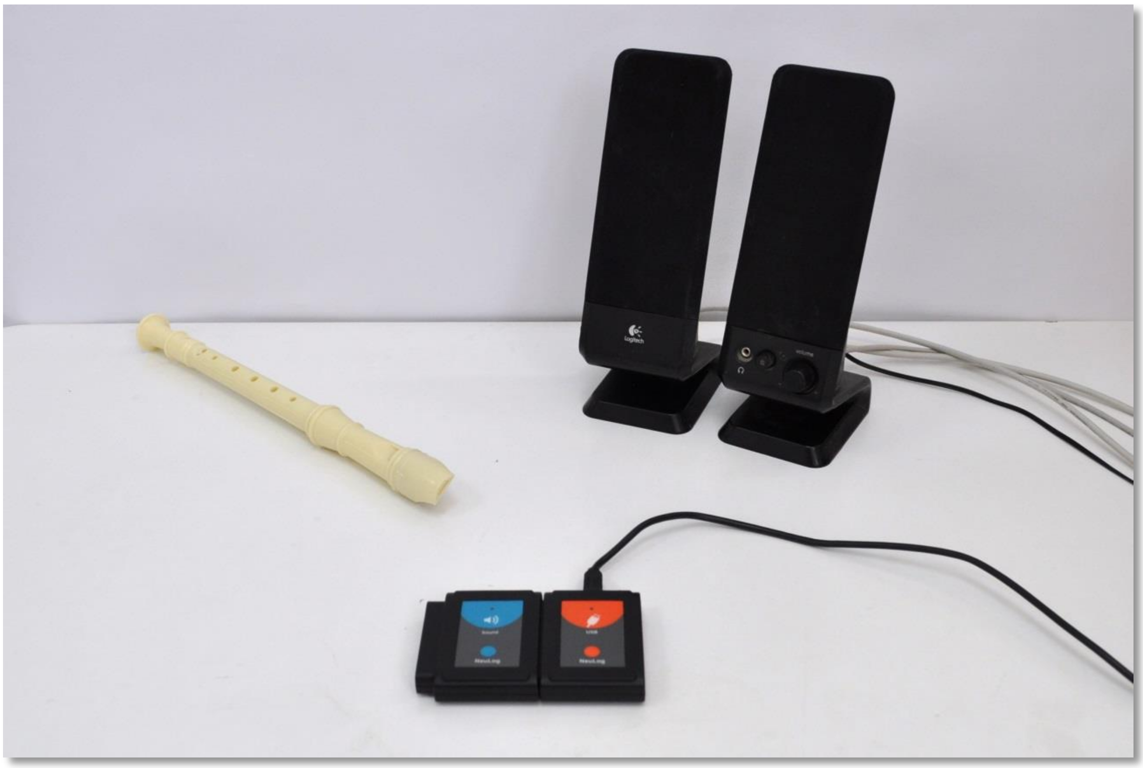
Hearing damage might instantly occur when sound intensities are above the threshold of pain, about 130 dB. A sound intensity of 85 dB, for over eight hours a day can also cause hearing damage.

In this activity, we will generate sound by whistling, clapping hands, using a musical instrument and an audio device; we will use a sound sensor to measure the intensities generated by the different sources.

Procedure

<u>Experiment setup</u>

1. Assemble a system like the one in the picture bellow.



2. Put the sound sensor on the table in front of one of the sound sources. Try to predict the sound level for each sound source.

Sensor setup

3. Connect the USB-200 module to the PC.

4. Check that the sound sensor is connected to the USB-200 module.

Note:

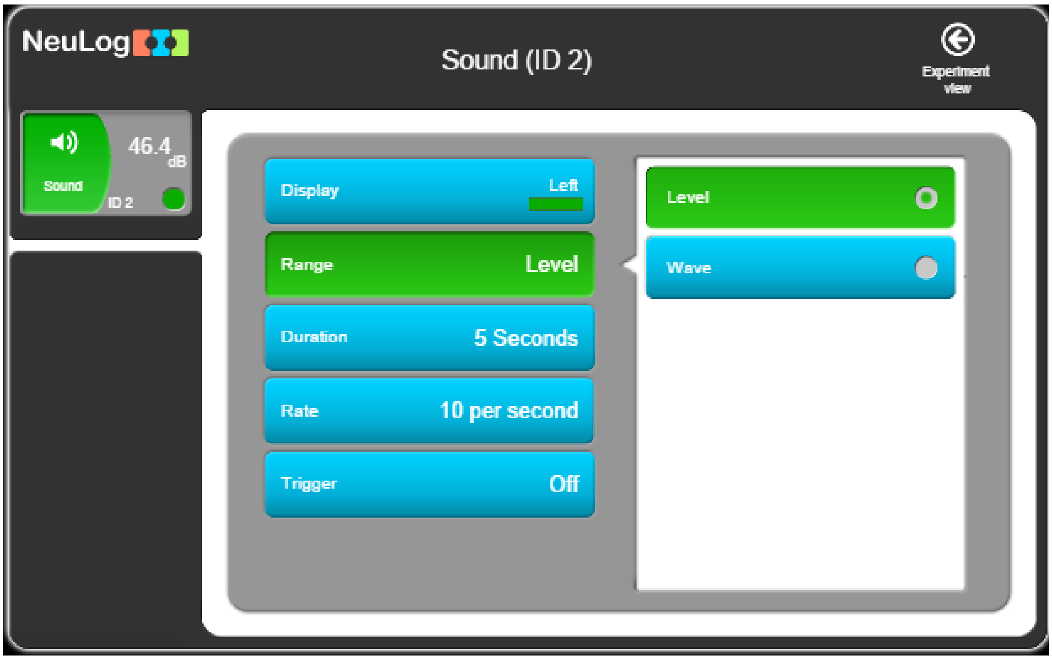
The following application functions are explained in short. It is recommended to practice the NeuLog application functions (as described in the user manual) beforehand.

5. Run the NeuLog application and check that the sound sensor is identified.

Settings

6. Click on the **Sensor's Module** box.

7. Select the Level button to set the sensor's mode.



8. Click on the icon to go back to the graph.

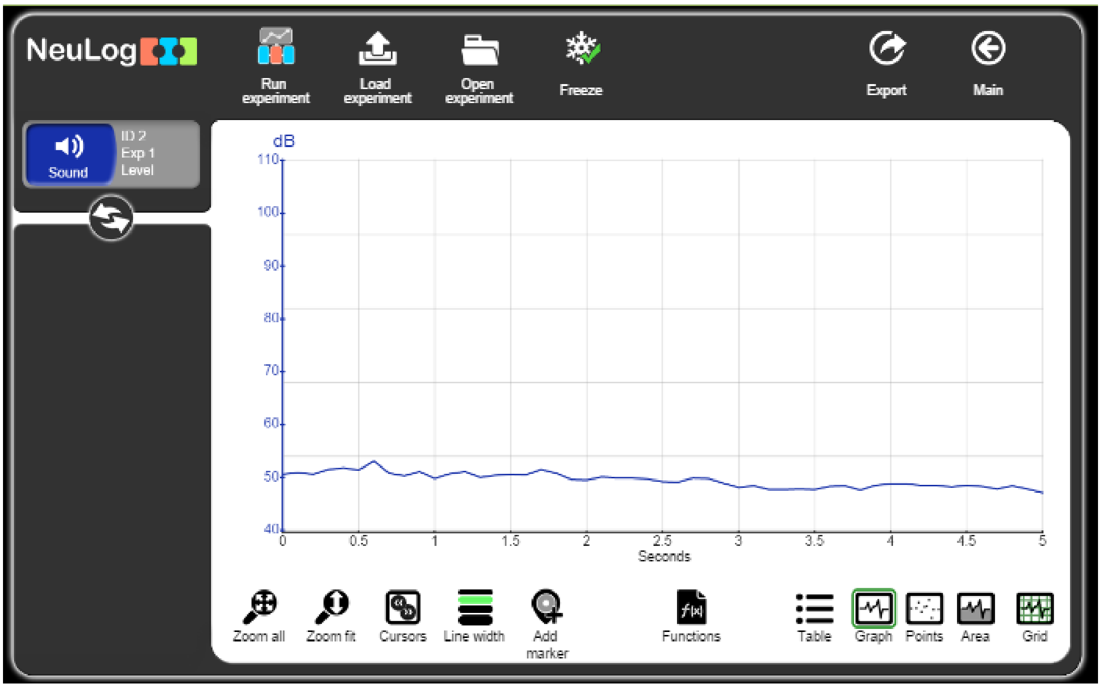
9. Click on the **Run experiment** icon and set the:

   Experiment duration to 5 seconds
   Sampling rate to 10 per second

Testing and measurements

We will make several measurements at different intensities. For example, first with the class as silent as possible. The following measurements will be: whistling, clapping your hands, playing a recorder or another musical instrument and turning on an audio device at a high volume.

10. Ask students to be as silent as possible and click on the **Record** icon to start the measurement.



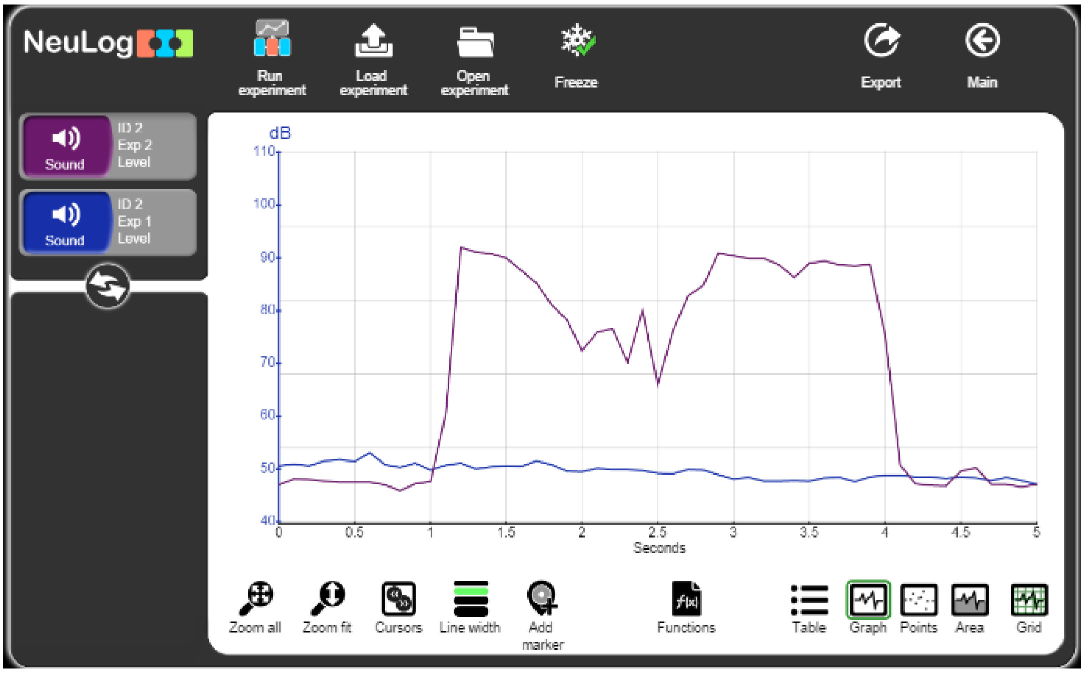
11. Click on the experiment's module box on the let of the screen. Look at the highest sample value.

Highest sample value: 53.1

The maximum level at silence is 53.1 dB for the sample experiment.

12. Click on the **Freeze** icon .

13. Generate a second level of sound by whistling and then click on the **Record** icon again.



14. Click on the experiment's module box on the let of the screen. Look at the highest sample value.

Highest sample value: 92

The maximum level of whistling is 92 dB for the sample experiment.

15. Repeat this procedure with at least two more sound intensities as previously discussed.

16. Write the maximal sound levels in the following table (below the sample data):

Sample experiment	
Action/sound source	**Maximal sound level [dB]**
Silence	53.1
Whistling	92
Clapping	75.2

Action/sound source	Maximal sound level [dB]
Silence	
Whistling	
Clapping	

Challenge research

17. Learn how to perform an offline experiment in the user's guide. Program the sound sensor with the same duration and sampling rate (5 seconds and 10 per second respectively); disconnect the sensor from your computer and try to find a quiet place to perform a measurement. Go back to the computer and see your results.

18. Repeat the last measurement but in a very noisy environment.

19. Measure the sound level of music from your earphones.

Summary questions

1. Observe the graphs you received and explain how the sound sensor helps you quantify the loudness of the sound.

2. Could you get measurements close to 40 dB?

3. Could you get measurements close to 120 dB?

4. Compare your results with the table in the introduction section.