Experiment P-33
Sound waves

Physics

Objectives

- To study sound waves produced by a tuning fork on a resonance box.
- To learn about period and frequency of sound waves.
- To understand how the length of the tuning fork affects its sound.

Modules and Sensors

- PC + NeuLog application
- USB-200 module
- NUL-212 Sound logger sensor

Equipment and Accessories

▪ A-426.6 Hz tuning fork
▪ B-480 Hz tuning fork
▪ C-512 Hz tuning fork
▪ Resonance box (wooden box)
▪ Hammer

- Each tuning fork has imprinted on its base the musical note and its frequency in Hz.

- The items above are included in the NeuLog Sound kit, SND-KIT.

Introduction

Sound is a mechanical wave that results from vibrating particles in a medium. Generally, sound waves are longitudinal waves so the motion of the particles is parallel (and anti-parallel) to the direction of the energy transport.

The particles of the medium vibrate at a given frequency (f). The frequency is the number of complete waves or cycles occurring in a unit of time, usually one second. The common units of frequency are Hertz (Hz); one Hz is equivalent to 1 cycle/second. The period (T) of a wave is the time for a particle to make one complete cycle. It is usually measured in a fraction of a second.

$1/T=f$
1/Period=Frequency
1/(The time it takes to complete one cycle) = (Number of waves that passes in a period of time)

The wavelength (λ) of a sound wave is the distance the sound travels in order to complete one cycle. The common units for wavelength are m or mm.

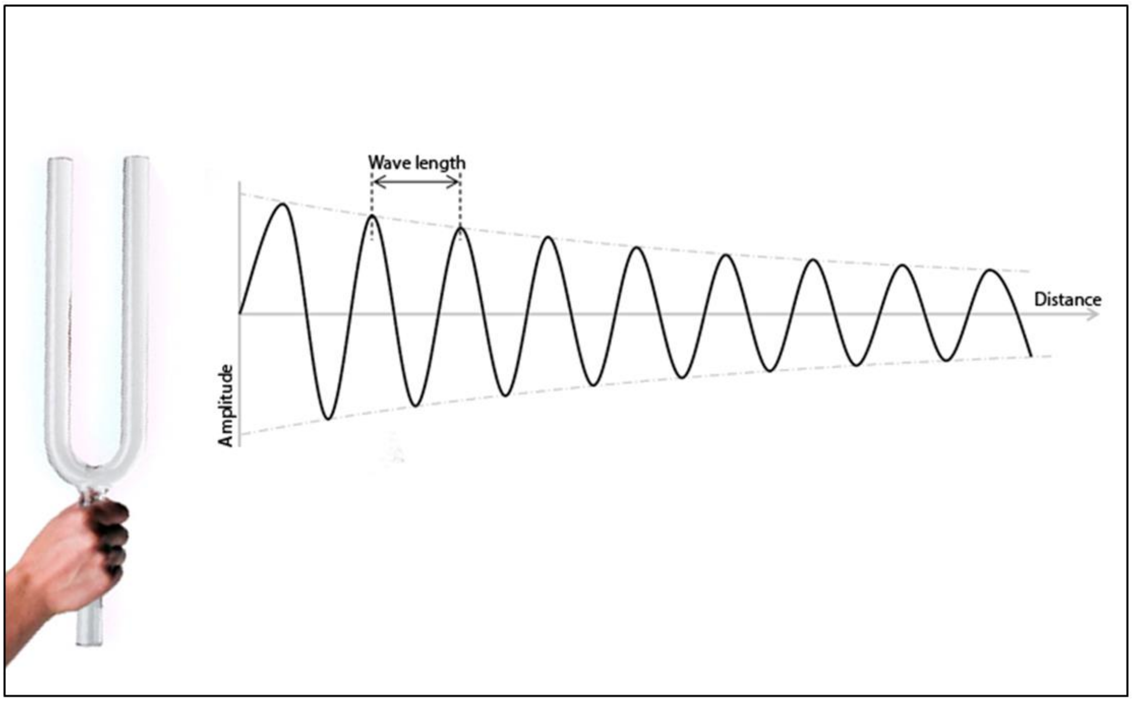
The sound wave's velocity (v) refers to the distance that the disturbance travels per unit of time. Velocity of sound waves is often expressed in m/s.

The mathematical relationship between frequency, wavelength and velocity is given by the following equation:

$v=f\lambda$
Velocity=Frequency X Wavelength
(Speed of the waves)= (Number of waves that pass in a period of time) X (the length of each wave)

Tuning forks are used by musicians, physicists and by anyone who is involved with sound and hearing. Tuning forks have two rectangular tines. The length of the tines affects the frequency of the fork. The two tines are joined on a stem.

When hit by a hammer, the tines vibrate back and forth pushing the air molecules around them. When the tine moves forward the molecules are pushed together creating a compression (high pressure region) and when the tine moves backward it creates a rarefaction (low pressure region). The compressions and rarefactions can be detected by a sound sensor (or a microphone).



The image describes the way sound waves are propagated by the tuning fork motion. The waves decay over distance (that is why we should measure them close to the tuning fork) and also over time (that is why the measurement should be started right after hitting it).

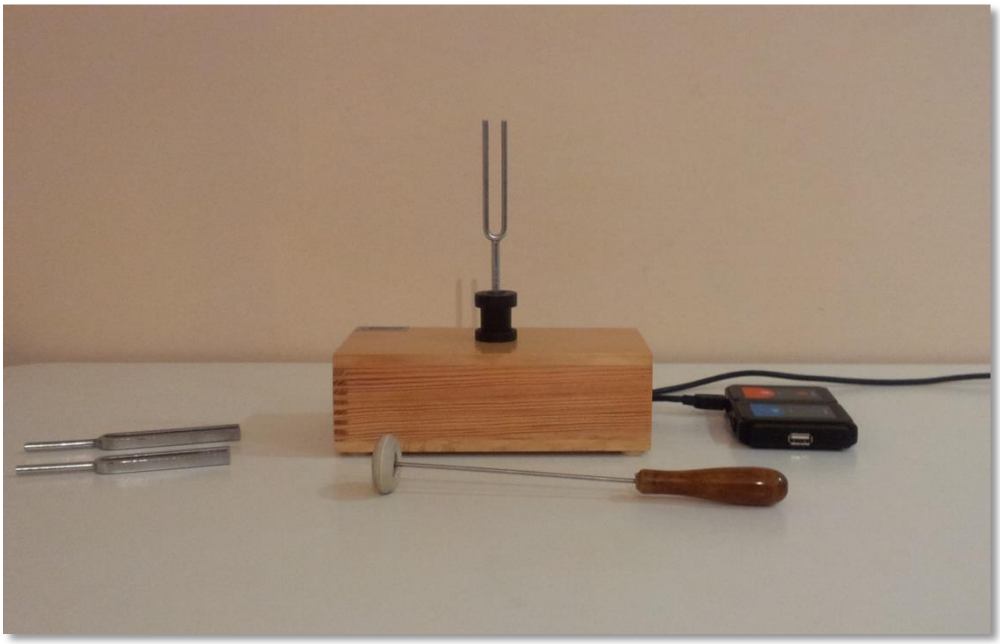
If the tuning fork is mounted on a resonance (wooden) box, when it vibrates it makes the air inside the box vibrate as well at the same frequency. This process increases the sound intensity of the tuning fork.

In this activity, we will use a sound logger sensor to measure the period and frequency of sound waves produced by three tuning forks with different lengths.

Procedure

Experiment setup

1. Set up the experiment as shown in the picture below.



2. Place the C-512 Hz tuning fork in the hole on top of the resonance box.

3. Place the sound sensor in front of the resonance box opening.

4. Hit the tuning fork with the hammer in order to produce sound.

5. Hit the tuning fork and then touch it; what happened to the sound?

Sensor setup

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

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

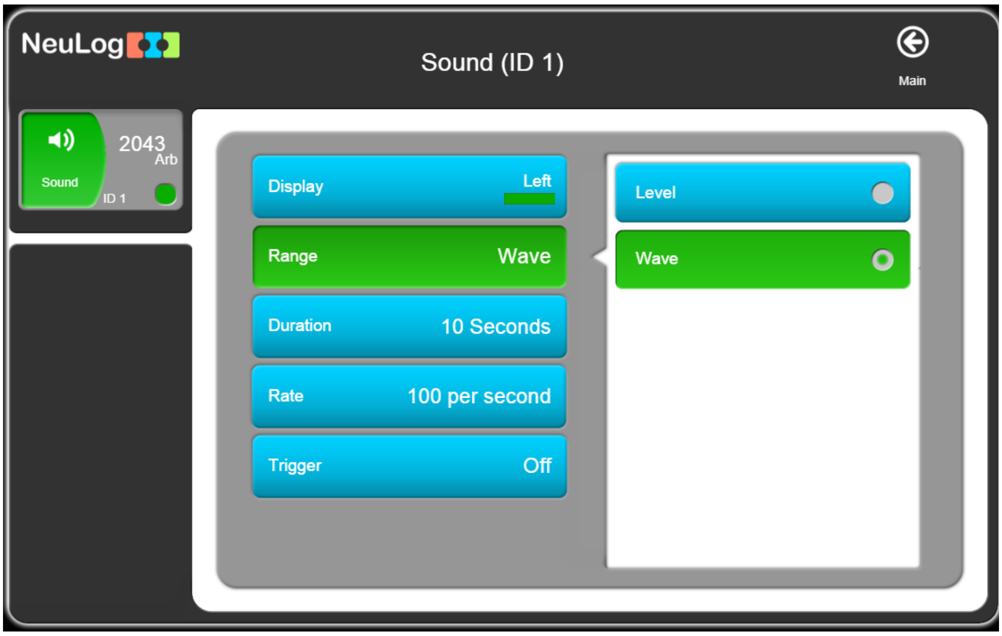
> Note:
>
> The following application functions are explained in short. It is recommended to practice the NeuLog application functions (as described in the user manual) beforehand.

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

Settings

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

10. Select the Wave button to change the sensor's mode.



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

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

    Experiment duration to 25 milliseconds
    Sampling rate to 10,000 per second

Testing and measurements

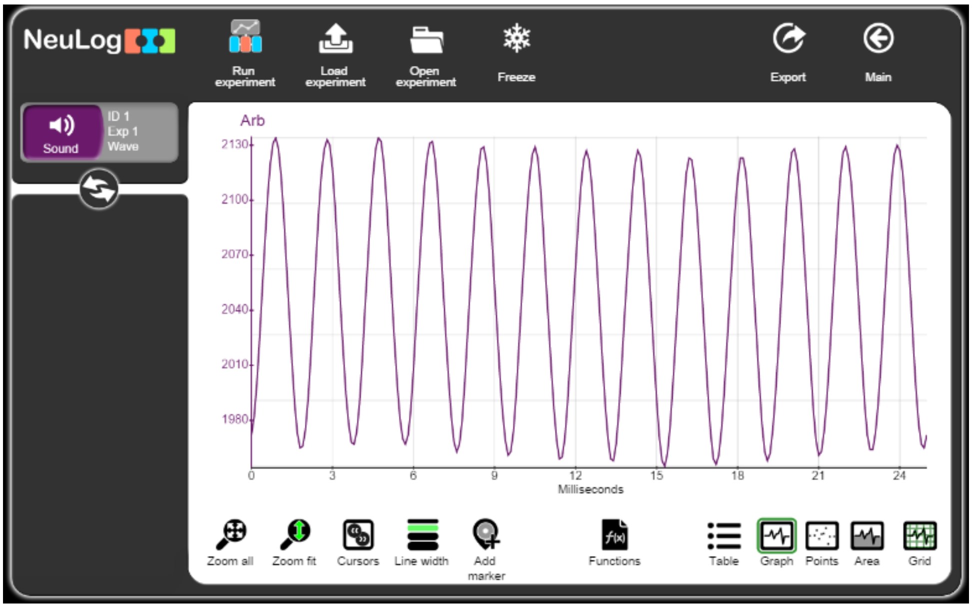
13. Hit the tuning fork with the hammer in order to produce sound waves.

14. Immediately, click on the **Record** icon  to start the measurement.

    This should be done quickly, while you can still hear the sound produced. If possible, one student should hit the tuning fork while another clicks on the **Record** icon .

15. Click on the **Zoom fit** icon .

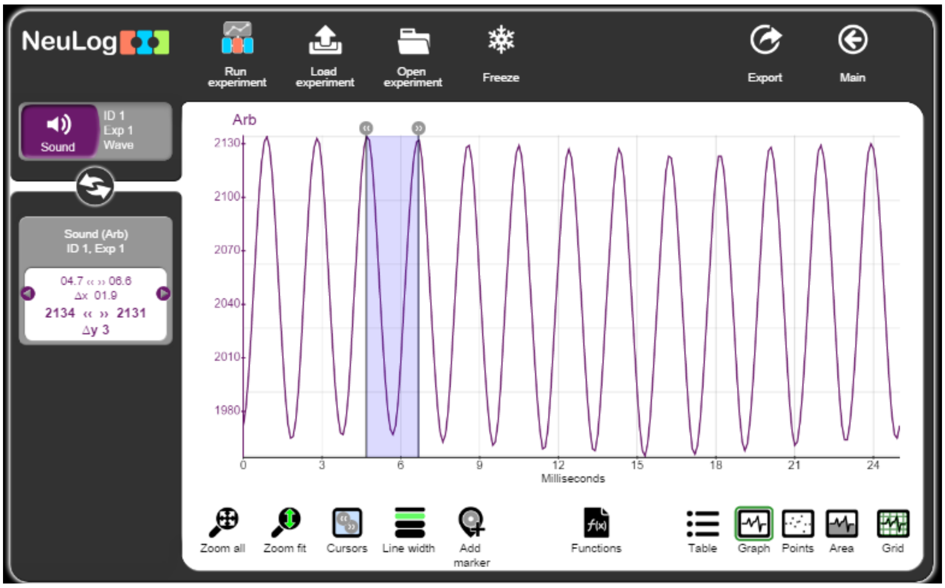
16. Your graph should be similar to the following (If not, repeat the measurement):

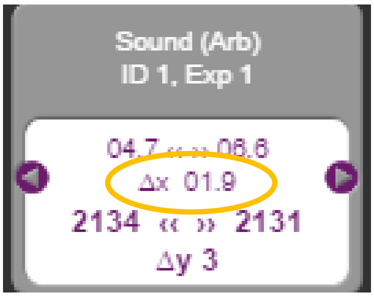


17. Click on the **Export** Icon  and then on the **Save value table (.CSV)** button to save your graph.

18. First we will calculate the period of the sound waves produced by the tuning fork.

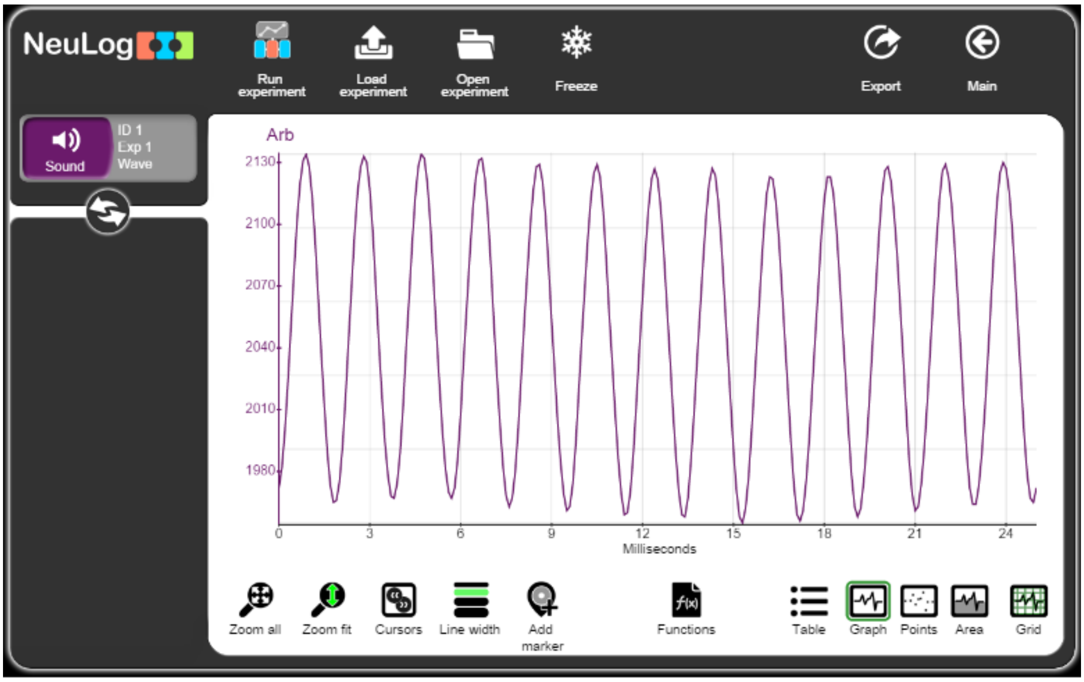
Click on the **Cursors** icon  and select the part between the beginning and end of one cycle.





19. The time it takes to complete one cycle is shown on the left side of the screen. In our case it is 1.9 milliseconds or 0.0019 seconds.

20. For a more accurate value of the period that includes all the range of our measurement, we will divide the measurement time, 0.025 seconds by the number of complete cycles, which in our case is around 13.



T= 0.025 s /13 = 0.00192 s = 1.92 ms

21. The frequency is equal to 1/period or alternatively it is equal to the number of complete cycles divided by the measurement time.

F = 1/0.00192 s = 520.8 s^{-1} = 520.8 Hz

Or

F=13/0.025 s = 520 s^{-1} = 520Hz

The frequency imprinted on the tuning fork is 512 Hz which is very close to our results.

Challenge research

22. Repeat the experiment using the A-426.6 Hz tuning fork and then the B-480 Hz tuning fork.

    Longer tines vibrate more slowly, therefore they produce lower frequencies and longer wavelengths.

Summary questions

1. Calculate the tuning fork sound waves period and frequency as demonstrated above (for all the measurements). Compare the calculated frequencies to the ones imprinted on the tuning forks.

2. What happened when you touched the tuning fork after hitting it? Explain.

3. Did you hear a difference in the sound produced by each tuning fork? What is the connection between frequency and pitch?