Investigation: Interference of Sound Waves

Introduction

A speaker produces sound waves using a vibrating cone which changes the pressure of the air around it. The wave travels outwards in every direction and eventually reaches your ears.

Sound waves have the same properties as other types of waves, such as reflection and interference. Interference occurs when two waves are passing through the same position. These can be waves from two different sources, or a wave from one source plus its reflection. Both constructive and destructive interference are possible. This will affect the loudness of the sound you hear.

In this experiment, we will investigate the interference of sound waves produced by speakers and how the result varies with position. We will use the interference pattern to find the wavelength of a tone and compare it with the theoretical wavelength.

1. Questioning and predicting

Let us think about the aim of this investigation.

1. What conditions are needed to produce interference between sound waves?
2. Where will constructive interference occur?
3. Where will destructive interference occur?

This diagram shows the wavefronts coming out of a speaker. Sketch what happens as they get further from the speaker.

Sketch the wavefronts coming from the second speaker (which is playing the same sound) and describe the results of the interference.



HYPOTHESIS

Regions where the waves interfere constructively will sound \_\_\_\_\_\_\_\_\_ (louder/quieter).

Regions where the waves interfere destructively will sound \_\_\_\_\_\_\_\_\_ (louder/quieter).

The spacing of maxima and minima depends on \_\_\_\_\_\_\_\_.

2. Planning investigation

This investigation has been planned for you. It is most suited to being performed by a whole class.

**Part A: Interference between two sources**

You will need a pure (sine wave) tone to be played through two speakers. This can be created by a signal generator, or by an online app/recording. The frequency should be about 340 Hz in order to produce a wavelength of about 1 metre – this will make it easier to find distinct points of interference.

1. Place the speakers on a desk, facing in the same direction about a metre apart, and play the tone.
2. Have one student stand approximately the same distance from both speakers, at least a metre away. The student should find the location where the resulting tone sounds the loudest and place masking tape or a chalk mark on the floor[[1]](#footnote-1).
3. Get a second student to start from the first mark[[2]](#footnote-2) and find a nearby point where the sound is loudest. Mark the location.
4. After 5-10 points of constructive interference have been found, repeat steps 2-4, this time finding locations where the sound is quietest. Mark these locations so they can be distinguished from the maxima.

**Part B: Interference with a reflection**

For this section you will need only one speaker, plus a strongly reflective surface such as a sheet of metal or tile. You should also use a small power meter, such as a smartphone app, to measure the resulting volume in order not to block the wave.

1. Place the tile approximately two wavelengths away from the speaker and play the tone.
2. Move the sensor/meter along the path of the sound to find the loudest and quietest regions.
3. Adjust the position of the reflector until the greatest difference between maximum and minimum volume is observed. This indicates that a standing wave has been formed.
4. Mark the positions of maxima and minima on the floor using masking tape.

3. Conducting investigation

After each part, take a photograph or draw a scale diagram showing where the regions of constructive and destructive interference occur as marked by the students. Compare the pattern obtained from Part A of the experiment with the pattern you drew in Section 1. On your photograph/diagram, sketch the locations of wavefronts from each speaker which would give you the pattern.

If time permits, you should perform this investigation for multiple wavelengths in order to compare results.

**Did you make any changes to the method? Did you have design problems to solve? Did you have some ‘smart’ ways of doing the investigation?**

4. Processing and analysing

What do you observe about the spacing of the loudest and quietest points compared to the wavelength of the sound? Do the How do they change with wavelength?

Measure the distance between the wavefronts. How does it compare to the approximate known wavelength of the sound?

Observe the pattern of maxima and minima obtained in Part B of the experiment. What can you say about the spacing between them? The distance between two neighbouring maxima or two neighbouring minima of the standing wave is equal to half the wavelength of the sound wave.

5. Problem solving

One way to think about the wavelength of a sound wave is as the distance between wavefronts. The shorter the wavelength (i.e. the higher the frequency), the further apart the wavefronts are. This will in turn affect the spacing of the interference maxima (completely constructive) and minima (completely destructive).

In Part A of the experiment, we used the characteristics of interference between two waves of the same wavelength in order to locate the wavefronts and hence make an experimental measurement of the wavelength.

In Part B of the experiment, we used the property of reflection to effectively ‘create’ a second wave travelling in the opposite direction. If we fit a certain number of wavelengths between the source and the reflector, we can create a standing wave where the maxima and minima are always in the same place. An animation of this can be seen at:

[https://commons.wikimedia.org/wiki/File:Standing\_wave\_2.gif](https://commons.wikimedia.org/wiki/File%3AStanding_wave_2.gif)

The distance between neighbouring maxima/minima gives half the wavelength.

Because we know the speed of sound in air, knowing the frequency of our generated sine wave allows us to make a theoretical calculation of wavelength using the wave equation:

$$v=fλ$$

Where *v* is the speed of sound (≈ 340 m/s) and *f* is the frequency in Hz.

The theoretical wavelength can now be compared to the experimentally measured wavelength.

6. Conclusions

Interference of sound waves with the same frequency can be measured via the loudness of the sound.

The spacing of maxima and minima depends on wavelength. The longer the wavelength, the \_\_\_\_\_\_\_ (closer/further) the maxima and minima.

1. If it is difficult or impractical for students to find regions of constructive/destructive interference by ear, a power meter can be used to measure the loudness in decibels at different locations. Smartphone apps can perform this task. [↑](#footnote-ref-1)
2. Tip: Ensure all students listen to/measure the volume at approximately the same height above the ground; sound waves travel in three dimensions and we are interested in the 2D pattern at one height. [↑](#footnote-ref-2)