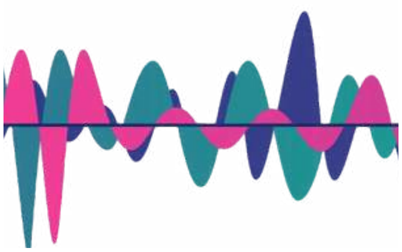
Sound



# Speed of Sound

## Overview

Have you ever wondered how **sound** travels through the air and reaches your ears? In this activity, you will explore how **sound waves** move and learn how to measure the **speed of sound**. Using a slinky and a ruler, you'll visualize **sound waves** and create **vibrations** that produce **sound**. With databot's sound sensor, you'll also analyze **sound waves** and measure the **speed of sound** using an **echo** experiment.

## Background

**Sound** is a type of energy that travels as a **wave**. These **waves** are created when an object vibrates, sending **vibration**s through a **medium** like air, water, or a solid. **Sound waves** are longitudinal waves, meaning the particles in the medium move back and forth in the same direction as the **wave** travels.

The **speed of sound** depends on the **medium** it travels through. For example, **sound** moves faster in solids than in gases because particles in a solid are more tightly packed. In air at room temperature, the **speed of sound** is approximately 343 meters per second (m/s).

When **sound waves** reach a surface, they can bounce back, creating an echo. By measuring the time it takes for the **echo** to return, you can calculate the **speed of sound**. This principle is often used in technologies like sonar and ultrasound. Understanding **sound waves** helps us learn how we hear, how musical instruments work, and how **sound** is used in communication and technology.

**Grades**: Middle School
**Time**: 45 Minutes
**Subject**: Physical Science
**Topics**: Sound, Sound Waves, Speed of Sound

## What You Will Need/Prep

- databot
- IOS/Android Smart Device
- Install Vizeey™ on your Smart device.
- Slinky
- Ruler or measuring tape
- Flask or tube with water
- Thread and marker

- Test your databot™ connection.
- You will be prompted to select and connect to databot™ each time you launch an experiment.
- If there are two or more databot™'s listed, the one closest to your device will be highlighted in blue.
- Study the background information and terms and prepare to explore!

## Learning Objectives

By completing this lab, you will:

- Understand the relationship between sound, wavelength, frequency, and speed.
- Identify and explain the conditions for resonance in an air column.
- Measure and record the length of an air column that produces resonance for a given sound frequency.
- Use databot to detect and record changes in sound intensity as the air column length changes.
- Analyze patterns in the recorded data to determine the wavelength of the sound wave.
- Calculate the speed of sound.
- Visualize and interpret sound wave data using graphs to connect experimental observations with theoretical principles.

## Important Terms

**Amplitude:** The maximum displacement of particles in the medium from their rest position, corresponding to the loudness or intensity of the sound.

**Air Column:** A confined space of air, such as inside a tube, where sound waves can reflect and create standing wave patterns.

**Echo:** A reflected sound wave that bounces back after hitting a surface. Used to calculate distances and measure the speed of sound.

**Frequency:** The number of complete sound wave cycles passing a given point per second, measured in hertz (Hz). Determines the pitch of the sound.

**Medium:** The material (e.g., air, water, metal) through which sound waves travel, significantly influencing their speed and behavior.

**Reflection:** The bouncing back of sound waves when they encounter a surface or boundary, necessary for forming standing waves in a resonating air column.

**Resonance:** A phenomenon where a system vibrates at maximum amplitude when the frequency of an external force matches its natural frequency, amplifying the sound.

**Sound Wave:** A vibration that travels through a medium (e.g., air) as a longitudinal wave, compressing and rarefying particles in the medium.

**Speed of Sound:** The rate at which sound waves propagate through a medium, dependent on factors like the medium's density and temperature.

**Wavelength:** The distance between two consecutive points on a wave that are in phase (e.g., from one compression to the next). It is related to the speed and frequency of the wave.

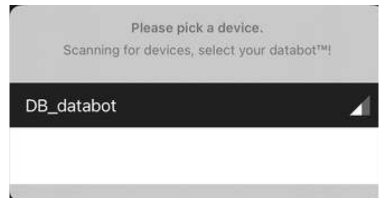
## Using Vizeey

In order to work with the experiment you need to launch the Vizeey application and click on + in the upper right corner.

Then select “Add experiment from QR code” and scan the QR code prepared for this experiment. Your experiment will appear in the list.

## Once in the Experiment

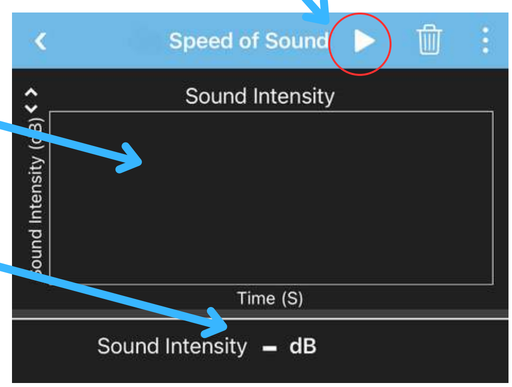
When you start the experiment you will be immediately offered to connect to your databot. Make sure that databot is turned on and in Vizeey mode with a blue blinking light.




This lab work investigates the intensity of sound.

- Graph showing the sound level
- Sound intensity value in real-time.

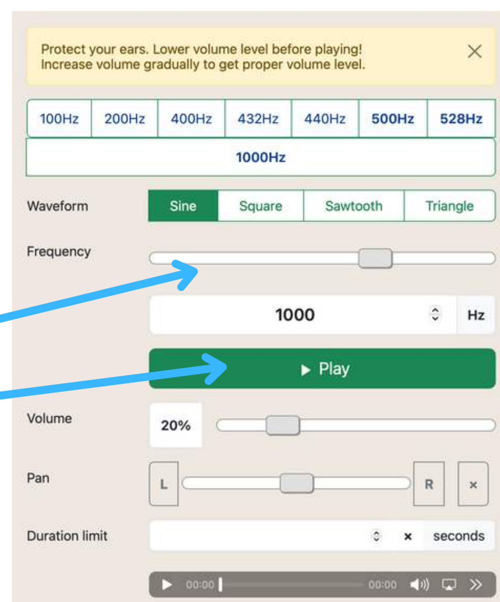
Press this button to start the experiment.




The lab work will involve generating a sound source of different frequencies. To do this, scan the qr code with your phone.

Set the frequency

Start the sound



## Part 1: Initial Observations and Discussion Questions

What is sound, and how does it travel through different materials?

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Can sound exist in a vacuum? Why or why not?

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What are some examples of sound waves we can't hear but are used in everyday life?

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## Part 2: Hypothesis

Based on your understanding of sound, propose a hypothesis about how the speed of sound could be measured using a databot sound sensor. Consider what data you might need to collect and how this data could be used to calculate the speed of sound.

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## Part 3: Experiment Procedure

Sound travels in waves, before we begin testing sounds let's look at how waves behave.

A wave is a repeating disturbance or vibration that travels through a medium or space, transferring energy from one point to another without the permanent movement of the medium itself. Waves can be classified based on their motion and direction of energy transfer.

There are several types of waves, transverse and longitudinal

A great way to observe wave movement and understand their differences is to use a long, flexible spring or a Slinky toy

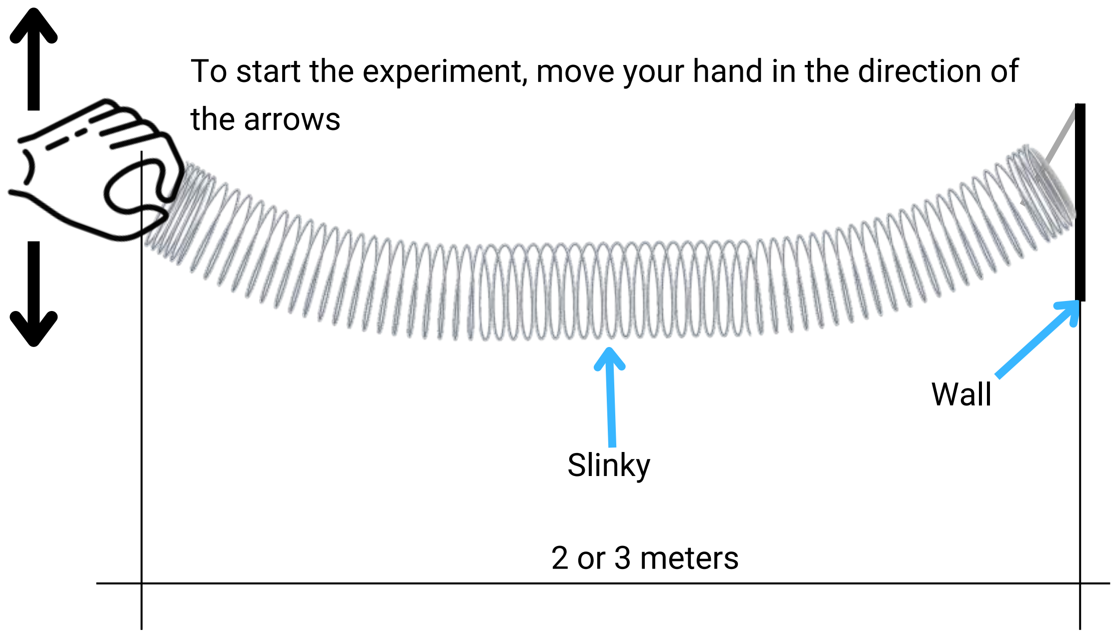
Slinky

Part 3: Experiment Procedure

Transverse Wave

A transverse wave is a type of wave where the particles of the medium move perpendicular to the direction of the wave's energy propagation. An example of a transverse wave is a wave on a string or light waves.

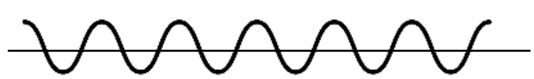
- Example: If the wave travels horizontally, the particles move up and down.




- Secure one end of the Slinky to a stable surface, such as a wall or a heavy object that won’t move.
- Stretch the Slinky gently to a length of 2-3 meters, ensuring it remains taut and steady.
- Wait for the Slinky to settle so it stops moving completely.
- Quickly move your hand holding the free end of the Slinky up and down in a sharp motion to create a wave.

What Happens.

When a wave is created, it will travel along the length of the Slinky. Once the wave reaches the anchored end, it will reflect back and move toward you. You can observe the continuous motion of the wave as it travels and reflects.



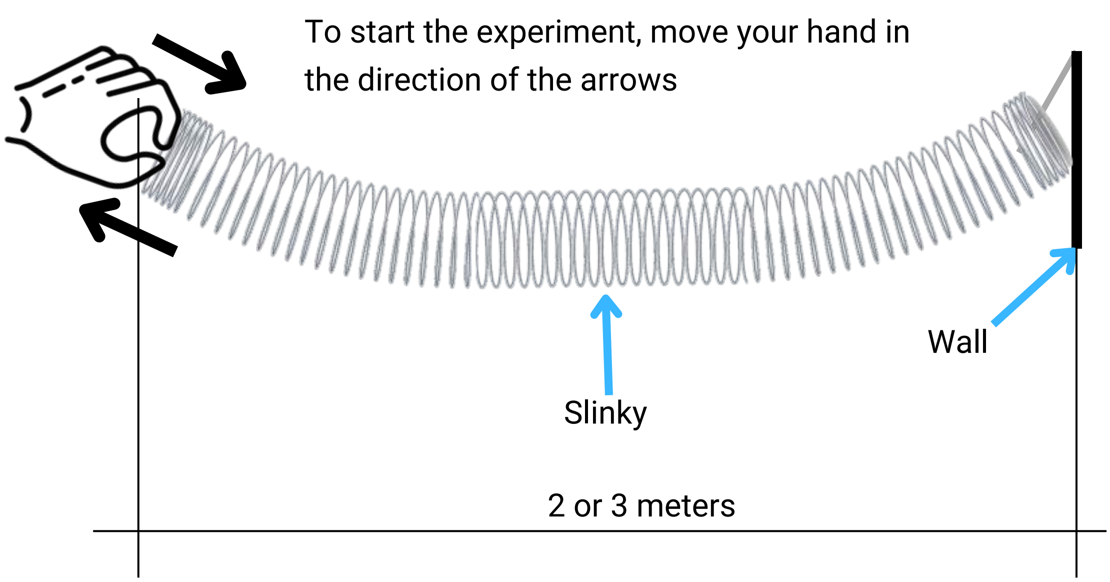
Transverse wave graph

Part 3: Experiment Procedure

## Longitudinal Wave

A longitudinal wave is a type of wave where the particles of the medium move parallel to the direction of the wave's energy propagation. Sound waves traveling through air are a common example of longitudinal waves.

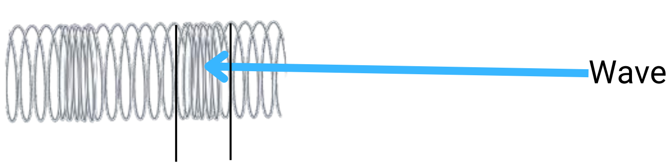
- Example: If the wave travels horizontally, the particles oscillate back and forth in the same direction.




- Secure one end of the Slinky to a stable surface, such as a wall or heavy object that will not move.
- Carefully stretch the Slinky to a length of 2-3 meters, making sure it remains taut and stable.
- Wait until the Slinky calms down and stops moving completely.
- Move your hand back and forth (in the direction of the arrows) to create a wave.

## What Happens.

A longitudinal wave will form and travel through the Slinky, resembling the way sound waves move through air. When the wave reaches the fixed end, it will reflect back toward you. You can observe the motion of the wave as it travels, reflects, and continues to move back and forth along the Slinky.

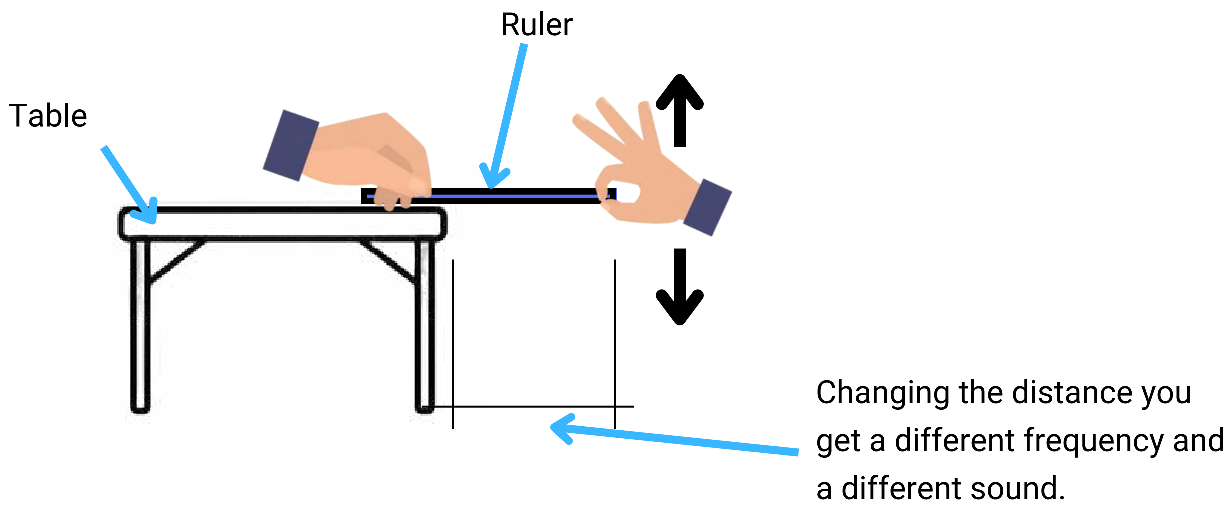


Part 3: Experiment Procedure

## Creating Sound

Sound is produced by any vibrating object. In this experiment, we will create vibrations with a ruler and observe how sound is produced.

Sound is a sensation created in the ear when sound waves reach it. These waves are caused by the vibrations of an object, like the ruler in this experiment. The air around the vibrating ruler acts as the medium, allowing the waves to travel to our ears. This simple demonstration helps to connect the concepts of vibration, sound waves, and perception of sound.




- Place the ruler on the edge of the table so that one part rests firmly on the table and the other part hangs off the edge.
- Hold the ruler down firmly on the table with your hand to keep it in place.
- Pull down the free end of the ruler and release it.
- Observe as the ruler begins to vibrate and produce sound waves.

## What Happens.

The vibrating ruler creates sound waves, which travel through the air (an elastic medium) to your ears. By adjusting how much of the ruler extends off the edge of the table, you can change the frequency of the vibrations and the pitch of the sound. More ruler hanging off the edge: Slower vibrations, lower pitch. Less ruler hanging off the edge: Faster vibrations, higher pitch.

## Part 3: Experiment Procedure

Now that you understand waves and sound, you can conduct an experiment to calculate the speed of sound using a hands-on approach. Sound waves travel at different speeds depending on the medium they move through. For example, the speed of sound in air (at room temperature) is approximately 343 m/s, which is what humans typically hear. In water, sound travels faster at about 1,480 m/s, and in solids like steel, it can reach speeds of over 5,000 m/s. These differences occur because molecules in solids and liquids are closer together, allowing sound waves to propagate more quickly. Using this experiment, you will focus on measuring the speed of sound in air.

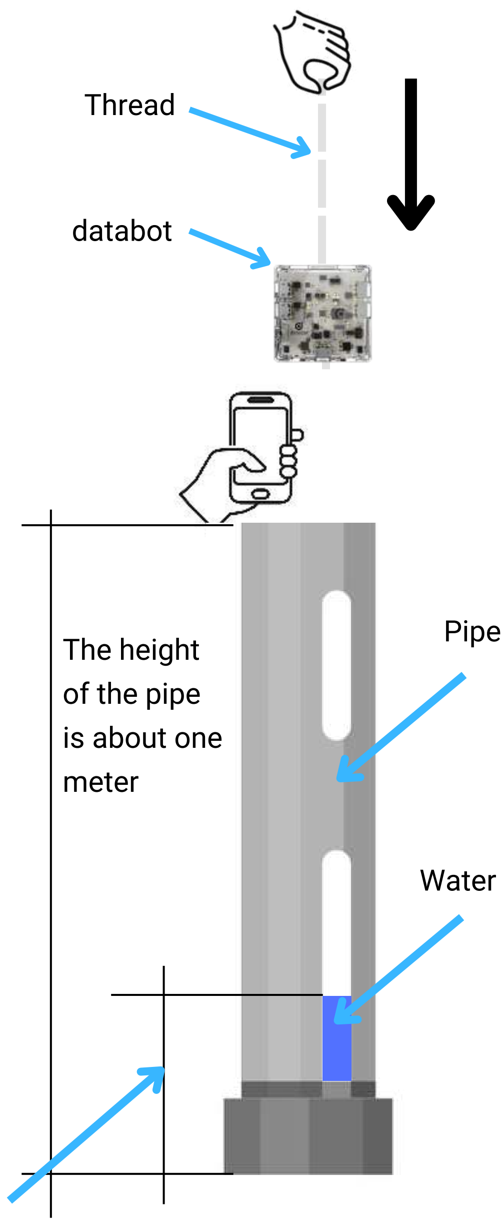
Experiment: Measuring the Speed of Sound Using Resonance in an Air Column.

Objective:

To calculate the speed of sound in air using the resonance method with an air column and databot.

Setup:

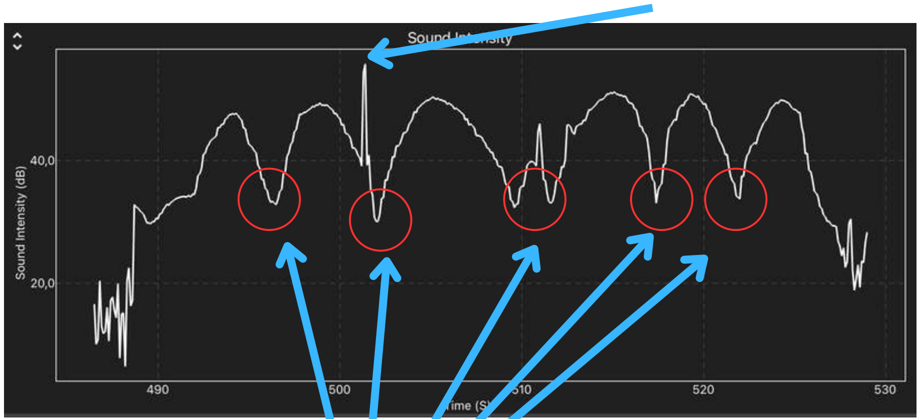
- Fill the tube partially with water, leaving some space for an air column above it.
- Ensure the tube is placed upright and securely fixed to prevent movement.
- Generate a Sound Wave:
  - Use the tone generator app on your smartphone to create a sound of a specific frequency (1000 Hz).
- Position the smartphone's speaker near the open end of the tube to send sound waves into the air column.

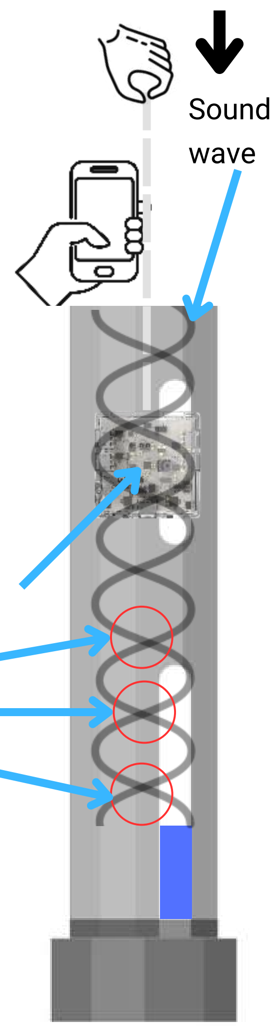


Part 3: Experiment Procedure

- Attach the Databot to a string to safely lower it into the tube.
- Open the Vizeey app on your smart device.
- Turn on databot (using the small button on the left side)
- Tap on **"Speed of Sound"** in Vizeey to load the experiment.
- You will be prompted to connect to databot.
  - Hint- if there is more than one databot in use, the one closest to you will be in blue!
  - A solid blue light on databot means you are connected.
- Start your experiment using:
  - Use these icons at the top of the screen in Vizeey to start and to pause the experiment.
- Gradually lower the Databot into the tube, observing the graph of sound intensity.
- Find the Resonance Points:

Databot hitting the pipe while lowering




Identify the points where the sound intensity peaks on the graph, these represent resonance.

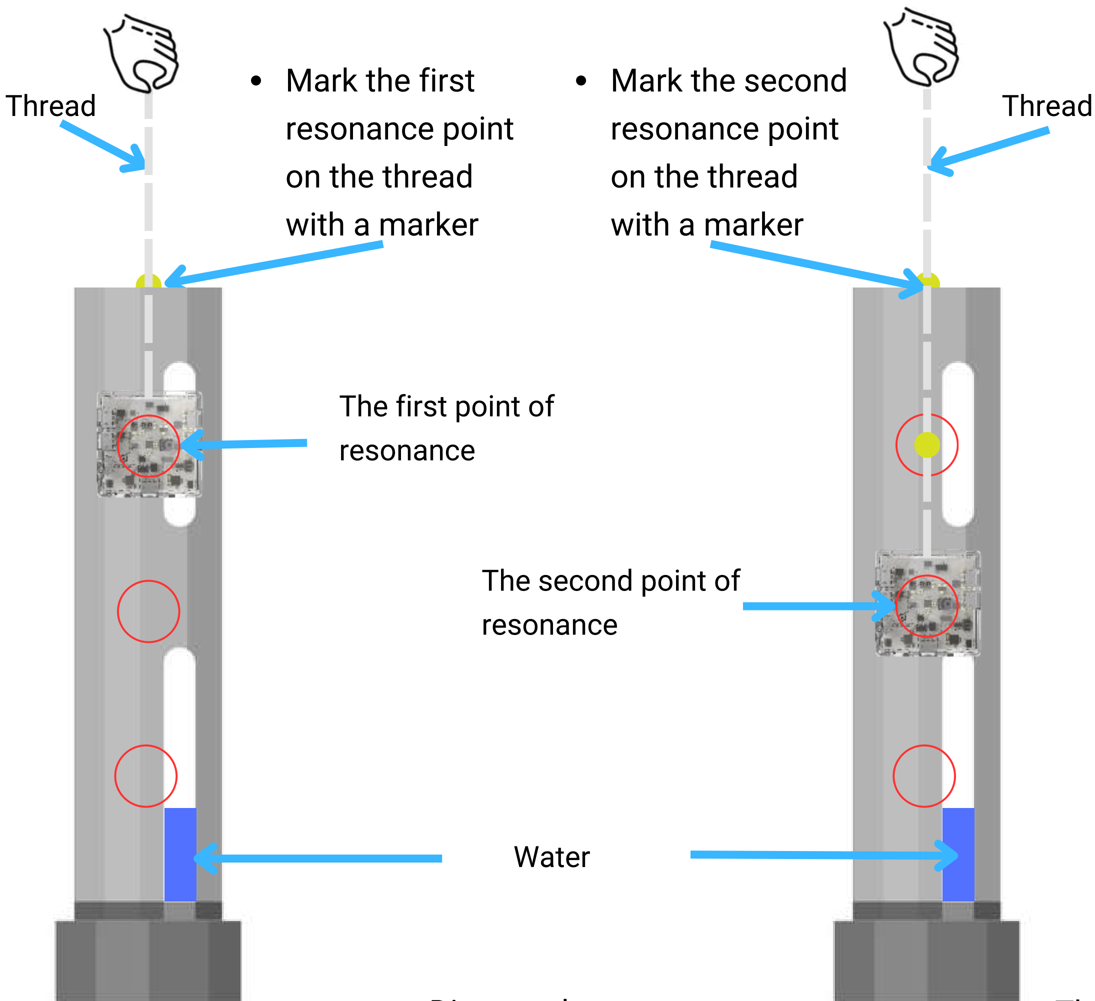
Be careful when lowering databot into the water pipe. Do not lower the device into the water. Water can damage the device

Part 3: Experiment Procedure

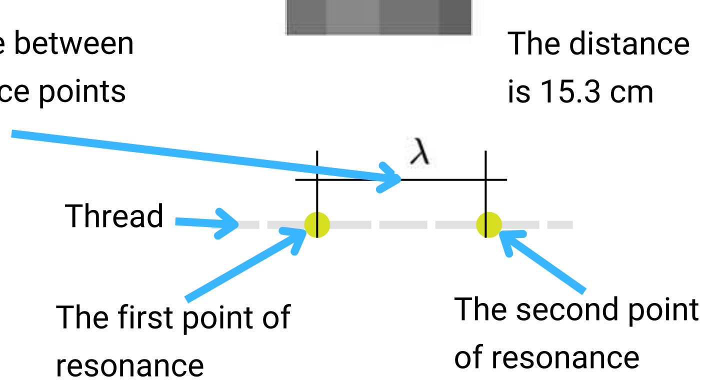
- Record the Resonance Points:
  - Measure the distance between consecutive resonance points (peaks).

When you've found the first resonance point, put a marker on the thread that you lower the databot with.

Lower the databot to the second resonance point and also mark it on the thread with a marker.




- Pull databoot out of the tube and measure the resonance point distances you marked on the thread



## Part 4: Data Analysis

The distance between two consecutive peaks corresponds to half the wavelength of the sound wave.

You have all the data.
To calculate the speed of sound, use the formula:

$$v = f \cdot \lambda$$

$f$ =1000Hz (sound frequency)

$\lambda$ = (wavelength) is equal to twice the distance between the peaks. ( during the experiment I got a distance of 15.3 cm )

$$\lambda = 2 \cdot 15.3\,\text{cm} = 30.6\,\text{cm} = 0.306\,\text{m}$$

Now, substitute the values:

$$v = 1000\,\text{Hz} \cdot 0.306\,\text{m} = 306\,\text{m/s}$$

The speed of sound is 306m/s.
The speed of sound in air under standard conditions (at 20∘C) is approximately 343 m/s.
The margin of error is approximately 10.8%.
That's an excellent result.

Do some of these experiments using different audio frequencies on your phone.
Do your calculations here and record the results in the table.

| Frequency (Hz) | Distance Between Resonance Points (cm) | Speed of Sound (m/s) |
|---|---|---|
| 1000 | 15.3 | 306 |
| | | |
| | | |
| | | |

## Part 5: Concept Questions

Data Interpretation:

What is sound, and how does it travel through different mediums?

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How are frequency, wavelength, and speed of sound related?

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Why does sound travel faster in solids than in air?

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Why do we see peaks and troughs in the intensity graph recorded by the databot?

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## Part 6: Reflection

1. What challenges did you face when identifying the resonant frequency during the experiment?

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2. How accurately do you think the databot captured the changes in sound intensity?

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3. In what ways could experimental error affect the calculation of the speed of sound?

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4. If given a chance, what would you modify in this experiment to improve its precision or efficiency?

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