PHYS 104 Lab 3 PHYSICS OF SOUND 1-Discovery lab

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Name……………………………..

**This week for your report provide answers to the questions and record your measurements in spaces provided in the manual. The space for the intro is on page 2 of the manual.**

Name……………………………...

Introduction

In this lab you will study sound waves and their behavior. You will use a **Sound Sensor** and two new **Data Studio** tools to in this experiment: the **Oscilloscope** and **Fast Fourier Transform (FFT)** to analyze the sound waves.

Theory

Just like other waves, sound waves are produced by vibrating objects. These objects create disturbances in the medium that surrounds them which then propagate away from the source through the medium. Today you will be able to examine the sound waves produced by a variety of sources including computer speakers driven by a sound generator that can be set to a specific frequency, your own vocal cords, and the tuning forks.

The first goal of today’s experiment is to establish connections between wave characteristics such as *amplitude* and *frequency* and how we perceive them.

The second goal is to examine sounds we humans produce and find what are the differences and similarities between different sound such as whistles, vowels and consonants. We will also look into differences and similarities of such sounds made by different individuals.

New Apparatus

In this lab you will use the **Scope** display of **Data Studio**,which is modeled after the oscilloscope, a commonly used instrument in electronics laboratories. It allows us to examine how a voltage varies with time. It this case it will display the voltage measured by the **Sound Sensor** which is proportional to the amplitude of the sound signal as a function of time, thus, effectively, you will be able to view the sound waves registered by the **Sound Sensor** and examine how they vary overtime. The **Scope** display looks just like an ordinary graph of voltage vs. time would, but the amplitude changes so rapidly that the **Scope** display resets itself quickly and then plots another graph.

Another tool you will use is the **Fast Fourier Transform** (**FFT**). All you need to know is that the **FFT** presents a graph of *relative sound intensity* vs. *frequency*. If a single *frequency* sound wave is produced, it will show a single peak at that *frequency* with *relative amplitude* of 1. If more than one *frequency* is present, then several peaks will show with the most intense one having *relative amplitude* of 1 and the others proportionately scaled. So, for example if 3 *frequencies* are present, you will see three peaks. If the *amplitude* of the lowest *frequency* is the strongest, its *relative* *amplitude* on the **FFT** display will show as 1. If second lowest *frequency* has the *amplitude* equal to 33% of the first, then its peek will show *relative amplitude* of 0.33 and if the third one (the highest *frequency)* has *amplitude* 70% as big as the lowest, strongest *frequency*, then it will show *relative amplitude* of 0.7.

**INTRODUCTION**

Procedure

1. Open the **Data Studio** and select **'Create Experiment'**. In the **'Experiment Setup'** from the list of sensors select the **'Sound Sensor'** and connect it to the analog channel “A” on the picture of the **'Interface Box'.**
2. Physically connect the **'Sound Sensor'** to analog channel “A” of the **Interface Box**.
3. Open the **Scope** and the **FFT** displays and place them so that you can observe both simultaneously.
4. Click the **'START'** button to begin recording data. The data should appear in the **Scope** and **FFT** displays. (Note: you may need to adjust the sample/s rate and turn on the triggering).

**Warnings:**

**The FFT does not always show the entire range of frequencies, so if you do not see the signal, you may want to extend this range.**

**Unfortunately, when the Scope and FFT work simultaneously, quite often the program crashes or gets hung up. The only thing to do then is to re-start the Data Studio. Be patient and, whenever one of the displays is not needed, close it. This can also happen if the sensor is overwhelmed by too strong a signal. Keep it a reasonable distance from the source.**

Throughout the lab record and discuss you measurements and observations. Try to draw conclusions about connections between sound wave characteristics and how we perceive them.

Part 1 Tuning Fork

In this section you will study wave patterns and *frequency* combinations for sounds produced by tuning forks.

1. Place sound sensor in a proximity of a tuning fork and then strike the tuning fork with a mallet and observe the **Scope** and **FFT**.

(You can click **'STOP'** button in **Data Studio** and freeze the display at any time. Then press **'START'** when you want to acquire new data)

1. Look at the **FFT** to determine if the sound has a single *frequency* or a combination of *frequencies*? List them below. Copy the graph into the space below.

Does the **Scope** show a “sine-like” wave? Copy the graph into the space above next to the FFT graph. Re-size graphs so that they fit side by side.

2. Strike the tuning fork again and observe what happens to the graphs as the sound dies down.

a) Look at the **FFT** and determine if the *frequency* affected. If so, how? Discuss.

b) Look at the **Scope** and determine:

Does the *period* change? If so, how? Discuss. Is this consistent with your **FFT** observation?

Does the *amplitude* change? If so, how? Discuss.

Part 2 Sound generator

In this part of today’s experiment you will study the sounds produced by a sound generator. Using the sound generator on the computer and computer speakers to produce sounds will allow us to control the volume and frequency independently. Note however that our computer speakers are not exactly high quality and are not designed to produce a wide variety of frequencies so do not go very far off from the recommended 337 Hz.

1. Click on the **'SweepGen'** icon on the desktop. Set the **'Sweep'** on manual, and the *frequency* range for **LF** (low frequency).
2. Place the **Sound Sensor** midway between the two speakers and keep it stationary.
3. Set the frequency of both speaker to 337 Hz and turn on the volume.
4. Click **'START'** button in **Data Studio** and use **Scope** and **FFT** graphs to assess:
5. Look at the **FFT** to determine if the sound has a single *frequency* or a combination of *frequencies*? List them below. Copy the graph into the space below.

b) Does the **Scope** show a “sine-like” wave? Copy the graph into the space above next to the FFT graph. Re-size graphs so that they fit side by side..

5. Use **Scope** and **FFT** graphs to assess what happens when you vary the *volume* while keeping *frequency* at 337 Hz.

a) Look at the **FFT** and determine if the *frequency* affected. If so, how? Discuss.

b) Look at the **Scope** and determine:

Does the *period* change? If so, how? Discuss. Is this consistent with your **FFT** observation?

Does the *amplitude* change? If so, how? Discuss.

6. Use **Scope** and **FFT** graphs to assess what happens when you vary the *frequency* (do not go to extremes here: see the note above) while keeping *volume* constant set at a comfortable level.

a) Look at the **FFT** and determine if the *frequency* affected. If so, how? Discuss.

b) Look at the **Scope** and determine:

Does the *period* change? If so, how? Discuss. Is this consistent with your **FFT** observation?

Does the *amplitude* change? If so, how? Discuss.

7. Can you now clearly establish how we perceive the *frequency* of a sound wave? Discuss (ask for help if you are in doubt).

8. Can you now clearly establish how we perceive the *amplitude* of a sound wave? Discuss (ask for help if you are in doubt).

9. Set the **'Sweep'** on manual by clicking the check box below the **'Manual Frequency Control'**. This unlocks the left and right speakers. You should now be able to control the *frequencies* of the two speakers independently. I’ll refer to the right speakers as #1. Set speaker #1 at 295 Hz. Try various *frequencies* for speaker #2 and observe the signals. In the end set speaker #2 at 337 Hz

a) Copy the **Scope** and the **FFT** graphs into the space below. Re-size graphs so that they fit side by side.

Does the **Scope** show a “sine-like” wave? Copy the graph into the space below. If it is not a sine graph, is it a superposition of two “sine-like” waves?

b) Is the signal periodic? (make sure to view sufficiently long time interval on the **Scope**-you may need to adjust the **Scope’s** horizontal scale). If so, measure its period, and calculate the frequency. Compare your calculation to the reading of the **FFT**.

10. Set the frequency of speaker #2 to an integer multiple of 295 Hz.

a) Copy the **Scope** and the **FFT** graphs into the space below. Re-size graphs so that they fit side by side..

Does the **Scope** show a “sine-like” wave? Copy the graph into the space below. If it is not a sine graph, is it a superposition of two “sine-like” waves?

b) Is the signal periodic? (make sure to view sufficiently long time interval on the **Scope**-you may need to adjust the **Scope’s** horizontal scale). If so, measure its period, and calculate the frequency. Compare your calculation to the reading of the **FFT**.

c) Try several integer multiples. Listen to the sounds and compared with non-integer multiples. Do combinations that involve *frequencies* that integer multiples sound more pleasing to your ear?

Part 3 Human Voice

1. “Whistle” a note into the sensor and observe the **Scope** and the **FFT**. (You can stop Data studio and freeze the display at any time)

Look at the **FFT** to determine if the sound has a single *frequency* or a combination of *frequencies*? List them below. Copy the graph into the space below.

Does the **Scope** show a “sine-like” wave? Copy the graph into the space above next to the FFT graph. Re-size graphs so that they fit side by side.

2. Use the **Scope** display and the **FFT** to examine the signals produced by a variety of sounds that you can make using your own voice. Try different vowel sounds such as “OO” to “EE” to “AH” to “UU” to “AY”. Then try different consonants e.g. “sh”, “ff”, “sss”, “rrr”. Try to keep the pitch and the volume of the sounds constant. (Again, make sure that you’re looking at a big enough range of frequencies. If needed adjust the scale).

For a single individual, copy and paste below the graphs (both displays) made for “oo”, “ee”, “ah”, “uu”, “sh”, and “ff”.

Then repeat for at least one more partner, preferably with the most dissimilar voice.

Before printing, please re-size all your graphs so we won’t waste too much paper. Six graphs can fit on one page.

3. Based on the observations made for the sounds you and your partners produced answer the following questions:

a) Which of the sounds consist of a single *frequency* and which are combinations of a number of *frequencies*?

b) Are any of the sounds made of *harmonics*? Support your answer with evidence.

c) Are any of the sounds *noise*? Support your answer with evidence.

d) Compare the sounds you made by you with the same sounds made by your partners- both how they sounded and what signals they produced on **FFT** and on the **Scope**. List all the differences and discuss.

**CONCLUSION**