Student's Name:

Circle Your Class Period: 5   7

Instructor: Ray Migneco

Introduction

In this activity, we will explore the properties of sound waves, namely *amplitude, frequency and phase*. In the process, we'll learn about some interesting properties of waves and how they are measured. Finally, we'll look at the relationship between pure tones and musical sounds.

Setting Up

1. Find a desk with a computer. If there isn't one available, find a partner to work with.

2. Make sure your Mac's volume is set to a reasonable level so you don't hurt your ears. The controls are located on the numbered keys.

3. Get a set of headphones from the instructor and plug them into the jack on the left side of the Mac.

4. Make sure that you're computer's volume is set at a reasonable level. Test the volume by using the keys at the top of the keyboard

5. Open up the FireFox web browser from the dock or type "FireFox" into the spotlight and hit "Return"

6. READ ON BEFORE DOING ANYTHING.

Reminders

1. The MacBooks are to be used for this activity only. Please close any open programs besides Firefox.

2. PUT YOUR NAME ON THE TOP OF THIS SHEET.

3. Put your answers to Response Questions in the space provided below the question.

4. Unless you have a partner, you should work alone and answer in your own words. You may ask the instructor if you have any questions on the lab.

Section 1: Background and Overview

In order to study waves, it helps to be able to see them to understand their properties. But waves are tricky because the ones that are easy to see, like waves in the ocean, are hard to study in the classroom... unless you can convince your teachers for a beach field trip. However, we are constantly surrounded by waves whether or not we are able to see them.

Response Question 1: Besides water and sound, what are two other types of waves that you've heard of?

All waves share the common property of traveling through some medium, such as air or water. In the case of sound waves, they are created by the rapid compression and decompression of air molecules. For example, clapping your hands together will create a sudden burst of sound. When the compression and decompression is *periodic*, or regular in its repetition, the resulting sound has a ptich, such as a beeping cellular ring tone.

Response Question 2: Based on your knowledge of how sound waves are produced, how do you think a speaker produces sound?

Section 2: Generating and Measuring Sound Waves

For the remainder of this lab, we will focus only on sound waves since they are one of the most common types of waves we encounter on a daily basis. In order to study sound waves in this lab, we need a means of generating and measuring them. To do this, we use two devices: A *Signal Generator* and an *Oscilloscope*. A Signal Generator does exactly what it sounds like: It produces a desired electrical signal that can be sent to a speaker (or headphones) in order to generate a sound wave. An Oscilloscope measures electrical current in a circuit and displays the signal on a screen.

To understand how the Signal Generator and Oscilloscope may be used, pretend for a moment that your iPod stopped playing music and you didn't know why. You might be able to find the problem by using a Signal Generator to insert a test signal into the iPod's circuit and measuring the different parts of the circuit with the Oscilloscope to determine where the signal drops out, which isolates the bad circuit.

1. **From the Firefox Browser toolbar, click on the link that says 'Frequency Display'. This should load a flash movie showing some controls and a wave plotted**

The display you see on your screen, The Tone Generator, is a combined Signal Generator and Oscilloscope. It will allow us to generate, measure and listen to sound waves in this lab.

2. **In the Tone Generator interface, move the slider labeled 'Phase Control' down until it reads 0.0. Then adjust the slider labeled 'Frequency Control' until the display below it reads '100 Hz'.**

3. **Press the 'Play Button' and move the slider labeled 'Amplitude Control' up and down and observe what you hear. Press the 'Stop Button'.**

<u>Response Question 3</u>**: How does the Amplitude Control slider affect the resulting sound? How can you relate this control to the description of how sound is produced (for example, clapping your hands)?**

4. **Set the 'Amplitude Control' slider to 50% and the 'Frequency Control' slider to 100 Hz. Press play, and move the 'Frequency Control' Slider up and down and observe what you hear (ignore the occasional clicking and popping sounds). Press 'Stop' when you are finished.**

Section 3: Wave Properties

So far we have analyzed two properties of sound waves, namely *amplitude* and *frequency*. As you may have observed, increasing the amplitude control also increased the strength of the sound. This is also why the maximum value of the wave shown in the Oscilloscope window increased as the slider was increased. Broadly speaking, amplitude measures the maximum strength of a wave.

The other property we observed with the sliders was *frequency*. Frequency refers to the number of times the wave oscillates in a given amount of time. You may have noticed the display reading "Hz" underneath the frequency slider. "Hz" is an abbreviation for "Hertz" or the number of cycles per second. Therefore, a wave with Frequency 100 Hz oscillates 100 times per second. Another way of putting it is that the wave can complete 100 cycles per second.

But what constitutes a cycle? For the sound waves we are studying, one complete cycle constitutes crossing the x-axis in both positive and negative vertical directions until the same exact point is achieved. An example of a full cycle is shown in the figure below. Notice how the end points of the wave are ap-

proximately the same value and you must trace your finger across the x-axis twice to end up at the original position.
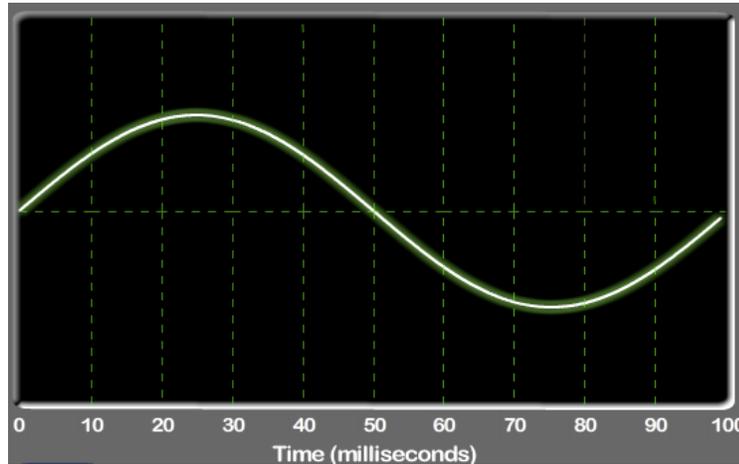

Figure 1: Example of one complete cycle of a wave

The amount of time required to complete a cycle is known as the wave's **Period** and is measured in seconds.

5. Using the Tone Generator, generate a signal that has a frequency of 65 Hz.

Response Question 4: Use the display to measure one period of this wave in milliseconds and report your result in the space below.

Response Question 5: What happens to the period of the wave when the frequency is increased? What about when the frequency is decreased? Explain your reasoning. You may use the Tone Generator to help answer the question.

As you may have observed from the previous questions, a relationship exists between the frequency and period of a wave. As the frequency increases, the wave period decreases since there are more oscillations in a given amount of time. Similarly, as the frequency is decreased, the amount of time required to complete a cycle increases, thus making the period longer.

The relationship between frequency and period is defined as:

$$T = 1/f$$

where T is the wave's period and f is the wave's frequency. Frequency and Period are described as having an inverse relationship, can you explain why?

A final property of waves we will discuss is **phase**.

6. Adjust the wave you have plotted in Tone Generator so that it has a frequency value of 100 Hz and a phase value of 0.

7. Using the blue arrow buttons, add a second wave to Tone Generator so that you see two distinct waves on the screen.

8. Adjust the sliders of the second wave so that the second wave has exactly the same amplitude, frequency and phase values as the first wave. The two waves should be overlapping each other exactly.

9. Begin increasing the phase slider for the second wave until you reach 180 and observe what you see.

As we adjust the phase of the second wave, we notice that its position in time changes with respect to the first wave. Phase is always measured relative to a reference wave. In our case, the first wave is the reference and when we changed the second wave's phase, we could describe it as being "out of phase" with respect to the first wave even though their amplitudes and frequencies were the same. The unit of phase is degrees since it describes the amount of shifting between the waves. If the second wave were set to have a phase of 180 degrees, it would look like the first wave reflected over the x-axis.

10. Set up the first and second waves so that they each have amplitude 50%, frequency of 110 Hz and phase equal to 0 degrees. The waves should exactly overlap each other.

11. Press the 'Play Button'.

12. Begin increasing the phase of second wave until it reaches 180 degrees and both waves are exactly out of phase.

<u>Response Question 6</u>: As you are increasing the phase difference between waves 1 and 2, what happens to the sound you hear as the phase difference nears 180 degrees. Why does this happen?