**Prelab: Measuring the Speed of Sound**

1. Sketch Prediction 1-1 on the axes below. Explain the reasoning behind your prediction in the space to the right of the graph.

2. Briefly explain what the oscillator does in Investigation 2.

3. Why is a short burst of sound used in Investigation 1?

4. Why is a continuous tone used in Investigation 2?
MEASURING THE SPEED OF SOUND

Topic: Sound, waves, basic kinematics

Overview: In this lab, you will measure the speed of sound by two different methods. In the first Investigation, you will use simple kinematics. A speaker will emit a brief burst of sound and you will use an oscilloscope to time how long it takes the brief burst to travel from the speaker to a microphone some known distance away.

In the second Investigation, you will use the wave properties of sound to measure the speed of sound. In lecture, you probably learned that the speed of a wave $v$ is equal to the product of its frequency $f$ and its wavelength $\lambda$:

$$v = f\lambda$$

A speaker will generate a continuous sound into a Lucite tube. A moveable microphone inside the Lucite tube will be used to “listen” to the sound at various places inside the tube. The frequency of the sound can be found by examining the output of the speaker on the oscilloscope or by reading the dial of the frequency generator that controls the production of the sound. The wavelength is found by comparing the oscillations emitted by the speaker to the oscillations “heard” by the microphone at various places in the tube. In this Investigation, the oscilloscope is used to monitor the oscillations emitted by the speaker and the oscillations detected by the microphone.

The oscilloscope is a device which displays voltage-time graphs of electrical signals. In this lab, the oscilloscope monitors two things: the electrical impulses that the speaker uses to produce the sound and the electrical impulses that the microphone generates from the sound.

In order to understand this lab, you need to be able to adjust the display that the oscilloscope produces and you will need to interpret the graphs it displays. However, you do not need to understand how the oscilloscope or any of the other electronics in this lab work.

Writing it up: Throughout this handout, you will be asked to answer questions, sketch graphs and do calculations. Write these things in your lab notebook as you go through the experiment. Label each answer/graph/calculation so that you (or your lab TA) can find things quickly. After lab, write a short (<300 words) conclusion of the experiment that summarizes what you did and the major findings of the experiment.

Safety/Equipment Notes:

There are no special safety considerations for the equipment in this lab.

Adapted from Dartmouth Lab: Sound Waves 10/29/03
Revised 10/29/03
Investigation 1: Using kinematics to measure the speed of sound

In this investigation, you will measure the speed of sound by timing the flight of a burst of sound as it travels from the speaker to the microphone.

1. The equipment should be set up as shown above. Pushing the red button on the speaker produces a short burst of sound. At the same time, an electrical signal is sent from the speaker to the oscilloscope. When the oscilloscope receives the signal, it begins to monitor the microphone. The microphone changes the sound it “hears” into electrical impulses and sends the impulses to the oscilloscope. The result is a graph of voltage versus time on the oscilloscope’s display. The time from when the sound was created to when it was received can be read from the oscilloscope by measuring the horizontal distance of the flat part of the voltage-time graph on the oscilloscope.

2. Set up the oscilloscope to measure the time of flight for the burst of sound. [NEED DETAILS HERE FOR SCOPE SETUP].

Prediction 1-1: You will measure the time it takes sound to travel from the speaker to the microphone for several different distances. Sketch a prediction graph for the resulting distance-time data. (Some questions to consider: Will the graph be linear? Will it go through the origin?)

3. Set the microphone at a known distance from the speaker. Record the distance. Push the red button and read the time of flight from the oscilloscope’s display.

4. Repeat the previous step for at least 5 different distances. Repeat the time measurement several times at each distance. (You might be surprised at the results!)

5. Make a distance-time graph from the data. Find the equation that best fits the data. Interpret the numbers in the fit equation.

   Q1-1: Compare the results with your prediction.
   Q1-2: You may find that the data do not appear to go through the origin. What does this suggest?
   Q1-3: You might be tempted to use the equation \( v = \frac{d}{t} \) to find the speed of sound from your data. Will this method give an accurate estimate of the speed of sound? How can you get a better estimate of the speed of sound from your data? Explain.
   Q1-4: Suppose the speed of sound was faster than the speed of the electrical impulses in the wires. Would this method be a good way to measure the speed of sound? Explain.

Investigation 2: Using wave properties to measure the speed of sound

In this investigation, you will measure the speed of sound using the wave properties of sound. The speaker will emit sound with a certain frequency. You will measure the wavelength of the sound by examining how the pattern on the oscilloscope changes as you move the microphone.

The equipment should be set up as shown above. The oscillator generates the electrical signal that drives the speaker. The frequency counter measures the frequency of the sound. The oscilloscope monitors the sound produced by the speaker and the sound received by the microphone.

Set up the oscilloscope. [NEED DETAILS HERE FOR SCOPE SETUP]

Activity 2-1: Changing the speaker’s output
In this activity, you will investigate how changes the speaker’s output affect the voltage-time graph the oscilloscope displays.

6. Turn on the oscillator. Record the frequency counter’s reading. Sketch the voltage-time graph that the oscilloscope displays in your notebook.

In the Spring-Mass Oscillator lab, you learned that the *period* is defined as one full cycle of the oscillation. In class, you may have learned that *frequency* is defined as the number of cycles of oscillation per unit time.

Q2-1: What is the mathematical relationship between frequency and period? (Even if you haven’t covered this in class yet, you should be able to deduce the relationship from the definitions above).

**Prediction 2-1:** Suppose you increase the frequency on the oscillator slightly. How will the voltage-time graph on the oscilloscope change? Explain. How will the sound you hear change?

7. Test Prediction 2-1. If the results don’t match your prediction, record the results in your notes.

**Activity 2-1:** Moving the microphone

In this activity, you will investigate how moving the microphone affects the voltage-time graph the oscilloscope displays.

**Prediction 2-2:** Suppose you move the microphone away from the speaker. How will the voltage-time graph change? Explain the reasoning behind your prediction. Suppose you move the microphone toward the speaker. How will the voltage-time graph change?

1. Test Prediction 2-2. If the results don’t match your prediction, record the results in your notes.

2. Move the microphone until the two sine curves on the oscilloscope’s display line up. Record the position of the microphone. Move the microphone around to find (and record) other positions of the microphone where the two curves on the oscilloscope’s display line up.

   Q2-2: Are these positions evenly spaced in space? How does the distance from one of these positions to the next compare to the wavelength of the sound? Explain.

3. Measure the wavelength as closely as you can. (Hint: Measure the total distance for several wavelengths and divide by the number of wavelengths). Read the frequency of the sound wave from the frequency counter. Use the result to calculate the speed of sound.

4. Repeat the previous step for at least two more frequencies. (Remember that changing the dial on the oscillator changes the frequency of the sound).

   Q2-3: Which frequency sound has the longest wavelength? Is this what you expect? Explain.

   Q2-4: How do the different values for the speed of sound compare? Does the speed of sound appear to depend on the frequency of the sound?