SPEED OF SOUND

The objectives of this experiment are:

- To measure the speed of sound in air.

APPARATUS: Dual trace oscilloscope, meterstick, sound tube apparatus, function generator

INTRODUCTION

Sound is a pressure wave that travels in a medium at a constant speed. The medium can be either a solid, liquid, or gas. Most experiences involve sound traveling through air. As it turns out the speed of sound depends on the type of gasses through which the wave is traveling. It also depends on the temperature of the gas, but not the pressure of the gas. The speed is also independent of the frequency or amplitude of the sound. For air, the speed of sound, c_s , in meters per second (m/s) is given by the relationship:

$$c_s = (331.4 + 0.6\,T_C) \text{ m/s,} \qquad (1)$$

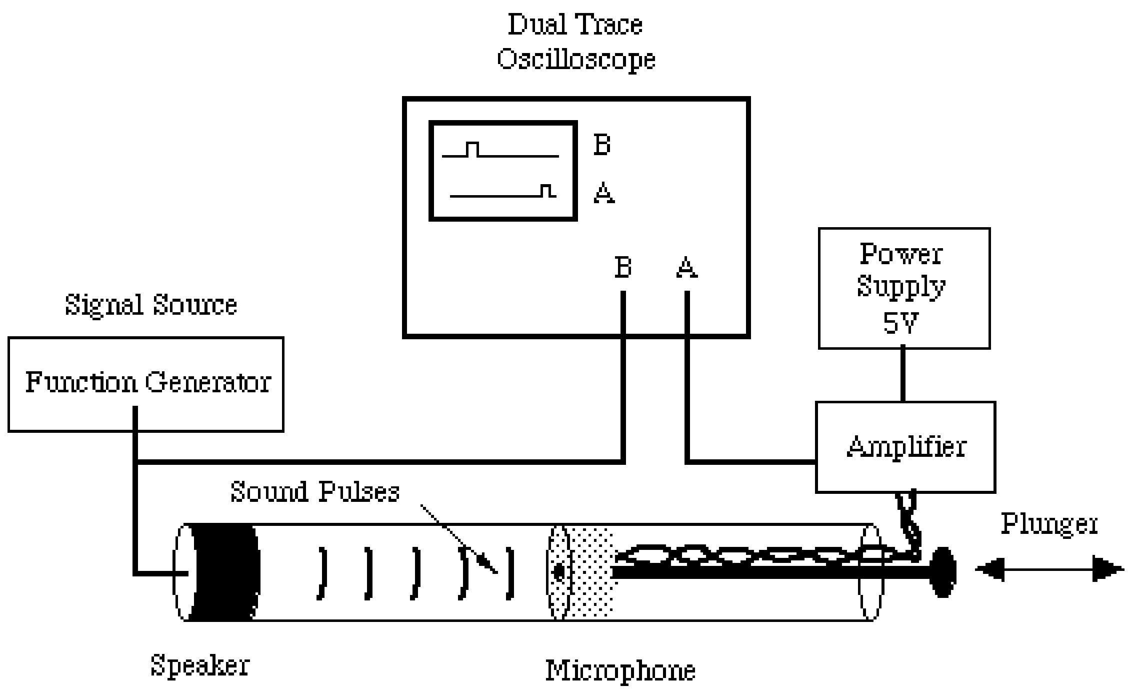
where T_C is the temperature of the air in degrees Celsius (sometimes called Centigrade). If you know the temperature in the Fahrenheit system you can convert to the Celsius system by using the conversion:

$$T_C = \frac{5}{9}(T_F - 32) \qquad (2)$$

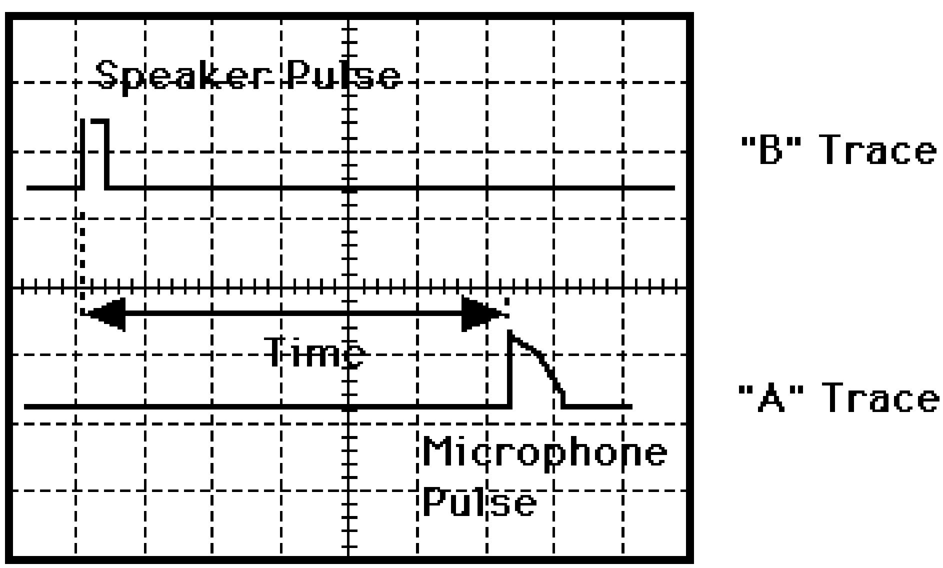
In this experiment you will use an oscilloscope to measure the time it takes a pulse (a "click") of sound to travel from a loudspeaker to a microphone. This is shown in the diagram below. The sound pulse is controlled by a function generator that produces a series of voltage pulses that are applied to the speaker. Each voltage pulse also "triggers" the oscilloscope so the oscilloscope beams starts sweeping across the screen at the instant the sound leaves the speaker. (The voltage pulse travels though the wires at the speed of light which is much faster than the speed of sound, so there is effectively no time delay due to the wires.)

The sound emitted by the speaker will travel down the tube through the air to a small microphone that, in turn, converts the sound pulse back into another voltage pulse. This output from the microphone is also relayed to the oscilloscope that displays this pulse as a second signal. The time delay is the difference between time of the initial pulse and the time it takes the sound to travel through air. (See next page to see how this is done.) The distance that the sound wave traveled through air is measured with a meterstick. So, you can calculate the speed of sound knowing the time it took the wave to travel that distance down the tube.

The following figure shows a schematic of the setup. Note that the distance between the speaker and microphone can be changed by pulling out or pushing in the plunger. The timing of the pulses is set with the function generator.



Below is a magnified view of the oscilloscope screen. The top trace "B" is the signal from the function generator which is sent to the speaker. The bottom trace "A" is the signal received from the microphone. The time delay between the pulses is measured from the screen.



For example, count the number and fractional parts of horizontal divisions. Here it is 6.2 divisions. Then, multiply this times the "TIME BASE" setting on the oscilloscope. Let's imagine that it is set to "0.2 ms per division". This equates to (6.2 div.) x (0.2 ms/div) = 1.24×10^{-3} seconds. If the distance traveled was measured and found to be 0.41 m, the speed of sound is 331 m/s.

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LAB REPORT FORM

NAME: ______________________________________ DATE: _____________

PARTNER(S): ____

In order to improve the accuracy of the experiment, make several measurements at various traveled distances. Measure the distance to the nearest millimeter. Also, measure the oscilloscope traces to a tenth of a division. Enter your data in this table and make your calculations. Compare your result to the theoretical value (Eq. 1) of the speed of sound. If there is no room thermometer assume that the room temperature is 20 C.

Temperature: _____________

Distance ( )	Time ( )	Speed ( )
	Average speed of sound =	

Theoretical Speed of Sound: _______________

$$\text{Percent Deviation} = \frac{(\text{measured speed}) - (\text{theoretical speed})}{(\text{theoretical speed})} \times 100\%$$

= __________ %

NOTES