Speed of Sound in metal

The principles used in the Speed of sound in air lab can be applied, to determine the speed of sound in a metal. Suitable apparatus for this purpose, is illustrated in Figure 9-2. Longitudinal standing waves are formed in the metal bar, by striking one end of the bar with a mallet.

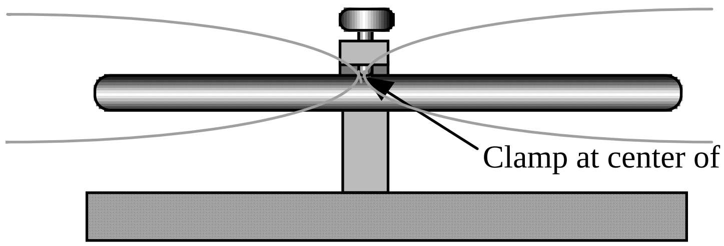

Figure 9 - 2

Since the bar is clamped at its mid-point a node forms there while antinodes form at the free ends, as indicated in Figure 9-2. If the bar is vibrating in its fundamental mode, then the **wave length of the wave in the metal is equal to twice the length of the bar**. If the frequency of the waves can be determined, equation [1] can be used to calculate the speed of the sound wave in the metal, i.e.,

$$v_m = \lambda_m * f_m \qquad [3]$$

where v_m, λ_m, and f_m are the speed, wavelength and frequency of the sound waves in the metal.

The vibrating end of the bar produces sound waves in air with a frequency identical to that at which the bar is vibrating, i.e.,

$$f_m = f_a \qquad [4]$$

where f_a is the frequency of the sound waves in air. Thus, by measuring f_a one can determine f_m and, thus, calculate the speed of the sound wave in the metal bar from equation [3].

A microphone is used to measure the frequency in air f_a and input it into the computer where the computer uses a Fast Fourier Transform technique (FFT) to convert the frequencies being received to a spectrum of amplitude vs. frequency. The rod or bar when it is clamped in the center and struck along its end will produce a fundamental frequency and this frequency will be displayed along with some of it harmonics, with the largest peak amplitude being the fundamental frequency of the rod or bar. It is this frequency that is used in conjunction with the wavelength (twice the length of the bar/rod) and equation [3] to determine the speed of sound in the bar or rod.

$$v_c = \sqrt{\frac{Y}{\rho}} \qquad [5]$$

Procedure

Speed of Sound in Metal

1. Close the current file and open the file speed of sound in metal in the 1401 folder.

2. Use the metal bar or long metal rod and make the measurements and calculations, in meters, to complete the appropriate portion of data table 2 . You only have to do either the bar or rod not both.

3. Determine where half the length of the bar/rod is and then at that point secure it into the clamp using a nail on the bottom of the clamp so that you are essentially clamping it at a point. See figure 9-2.

4. Position the sound sensor near one end of the bar/rod. Select the Start button. Rap the bar/rod along its end to send a longitudinal wave down the length of the bar/rod. Observe the Spectrum window on the computer screen. You should see a large peak which rises and fall to the tone created by the rod/bar as you strike it on its end. Select the stop button when a large peak is displayed within the window. The peak should remain on the screen. If not ask your instructor.

5. Choose the smart tool button and position it over the central part of the peak. You can use the arrow keys on the keyboard for small adjustments The frequency will be displayed next to the square box (frequency, intensity). Record this value as frequency f_m in data table 2.

6. Determine the velocity from the equation below. This will be the measured value of the velocity.

$$v = \lambda f$$

7. The metal used is aluminum and its Youngs Modulus is given on the data sheet. Use the equation [5] and your calculation for density, ρ, to calculate the value of velocity v_c. Complete the data sheet.

Data Sheet 1

Table 1

Bar	Material V=lwh
Length, l	
Width, w	
Height, h	
Volume, V	
Mass,m in kg	
Density ρ=m/V	
λ_m = 2* Length	
frequency f_m	
velocity v_m	
Youngs Modulus Y	
velocity v_c	

Rod	Material $V = \pi r^2 * l$
Length, l	
Diameter	
Radius, r	
Volume, V	
Mass,m in kg	
Density ρ=m/V	
λ_m = 2* Length	
frequency f_m	
velocity v_m	
Youngs Modulus Y	
velocity v_c	

Young's Modulus for Metals (in N/m^2)
Aluminum (6.7 ± 1.0) x 10^{10}

Determine the percent difference for the calculated value for the speed of sound in the metal to the measured value?