String Vibrations

w/ Variable String Lengths

Leader: ______________________________ Recorder: ____________________________

Skeptic: ______________________________ Encourager: __________________________

Equipment Needed

Block, Wood w/ angle
Clamp, Humboldt (black)
Mass Hanger, 50 g
Mass Set, Gram
Paper, White
Pulley, Table Clamp
Scale, Digital
Vibrator, String

Theory

A wave travels down a string with a velocity:

$$v = \sqrt{\frac{T}{\mu}} \qquad \text{Equation 1}$$

where

T is tension and

μ is the linear density in mass of the string per unit length

where

$$\mu = \frac{mass_{string}}{lenth_{string}} \qquad \text{Equation 2}$$

The wave reflects from a rigid end and travels back. If the string is an integral number of half wavelengths long, the string will resonate and display this number of 1/2-waves as in Figure 1. The wavelength is:

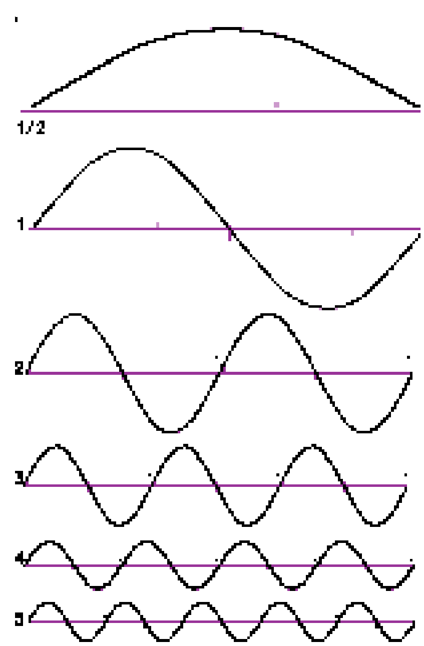
$$v = f\lambda \qquad \text{Equation 3}$$

If we combine Equation 1 and Equation 3 we get

$$f\lambda = \sqrt{\frac{T}{\mu}} \qquad \text{Equation 4}$$

Solving Equation 4 for f we get

Figure 1



$$f = \frac{\sqrt{\frac{T}{\mu}}}{\lambda} \qquad \text{Equation 5}$$

Figure 2 shows a typical half-wave. Figure 3 shows an actual photograph of the same half-wave.

Figure 2

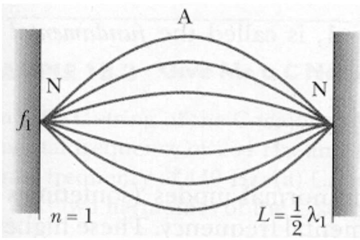
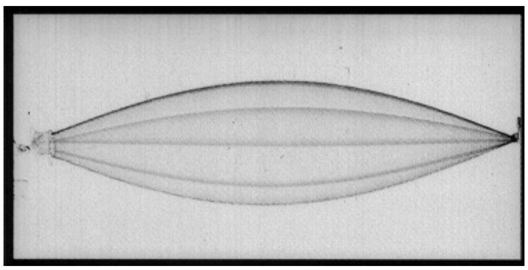


Figure 3



Figures 4 and 5 show a full wave.

Figure 4

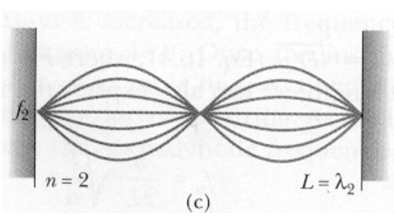


Figure 5

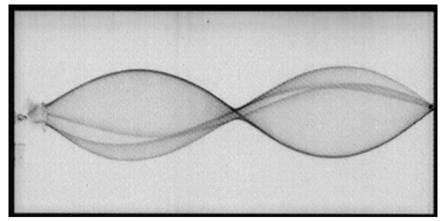


Figure 6 and 7 demonstrate $\frac{3}{2}$ wavelengths.

Figure 6

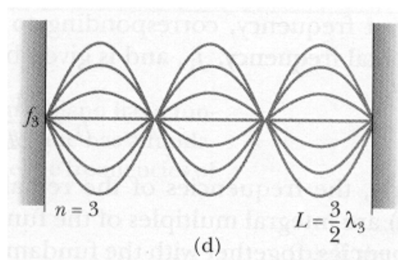
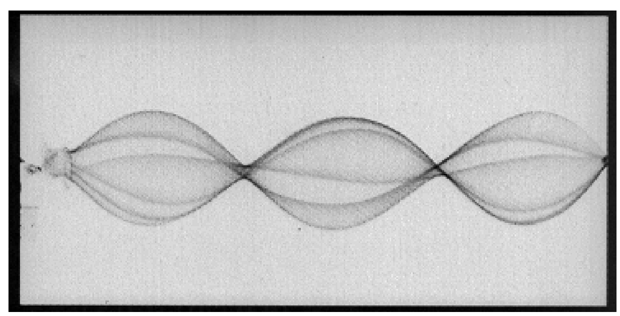


Figure 7



Procedure

1. Figure 8 shows how to anchor the vibrator in place with the Humboldt clamp.
2. Figure 9 shows the wood block, pulley and string arrangement.
3. Figure 10 shows the pulley and weight arrangement.
4. Begin with a mass of 125 g. The block should start out close to the pulley. You will be moving the block slowly toward the vibrator until a resonant frequency is achieved.

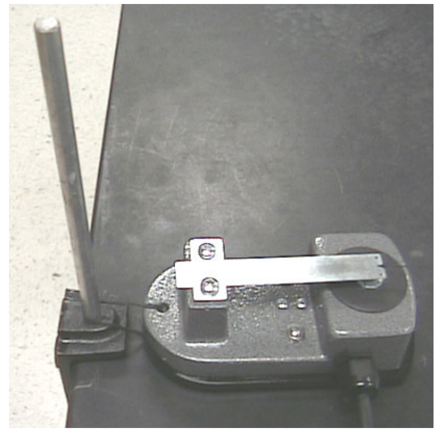


Figure 8

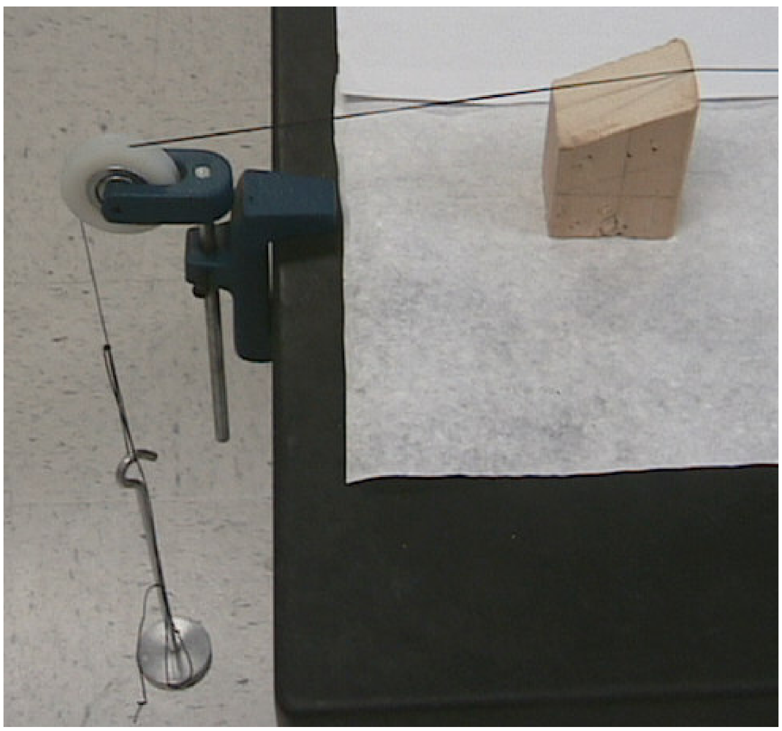


Figure 9

Figure 10

5. You should be able to see the wave in the string similar to the illustration in Figures 3, 5, or 7. The tighter the nodes the better your wave is resonating.

   Special notes and hints:

   a. The configuration should resemble one of the illustrations. If the end with the vibrator is NOT A NODE then don't include the 1st segment in your data.
   b. White paper under the string makes the waveform easier to see.

c. Try not to allow the hanging mass to swing.

d. You need to find the wavelength of one wave for your calculations.

i. $\lambda = \frac{2L}{n}$

ii. Where:

L= the length of the string from the reed to the wood block.

n= the number of antinodes. n is an integer.

6. After you find the first resonant point continue to move the block toward the vibrator until you find another resonant point. You can find 2, 3, or possibly as many as four resonant points over the length of the string. We will initially plan to get two resonant frequencies for each mass.
7. When you have gathered all the data for the 125g. mass add 25g. to the hanger and go through the data gathering procedure again getting two resonant points.
8. Continue adding 25g. increments from the hanging mass until you reach 250g. Don't forget to include the mass of the weight hanger itself. (Your instructor may want you to do more or less.)

Data Table

Don't forget to include the mass of the weight hanger

Hanging Mass M (kg)	Tension T = Mg (kgm/sec^2)	L (m)	n anti-nodes	$\lambda = 2L/n$ (m)	Velocity, v $(T/\mu)^{1/2}$ (m/s)	f = v/λ (Hz)	% difference (from 60/120 Hz)