Standing Waves on a String

Purpose: To study standing waves in a string and thus determine their velocity - both experimental and theoretical.

Apparatus: Lightweight string, weight hangers, weights, clamps, pulley, oscillator, stroboscope.

Introduction: Standing waves can be produced on a string tied at both ends if the frequency, f, is related to the length of the string, L, by

$$f = \frac{nv}{2L}, n = 1, 2, 3, \ldots \qquad Eq.1$$

where v is the velocity of the waves. The wave velocity is related to the tension in the string, T, and the mass per unit length, $\mu = \frac{m}{L}$, by

$$v = \sqrt{\frac{T}{\mu}} \qquad Eq.2$$

Procedure:

1. Connect the flexible, lightweight cord to the oscillator and attach a weight hanger so that the cord passes over a pulley. Use a length of cord such that the distance between the pulley and the oscillator is about the length of the laboratory table
2. Start the oscillator, and then by adding weights to the hanger, adjust the cord tension until two complete waves result (four loops). This is a transverse standing wave. Note that there are points on the cord where the displacement of the cord from equilibrium is zero. These points are called nodes. Likewise, there are points where the displacement is a maximum. These "loops" are called anti-nodes. Carefully adjust the hanging weight so that the amplitude of the anti-nodes is a maximum. Measure the wavelength, λ, of the standing wave that is in the center portion. (Neglect the one-half wave at each end.) Record the hanging weight.
3. Reduce the hanging weight in succession so as to obtain measurements of the standing waves with five, six, seven, and eight loops (half waves). Determine the wavelength for each case. Record for each the amount of the hanging weight.
4. Obtain the frequency of the oscillator using a photocell and light source (see your instructor).
5. For each of your five standing waves, calculate the wave speed using your determination of the oscillator's frequency (which is the same as the frequency of the standing wave that you developed on the string) and the wavelengths that you measured in step 2. What is the relationship between wave speed, frequency and wavelength?
6. Obtain measurements so that the mass per unit length, μ, of the cord may be found.

   Note: During the course of the experiment determine if the elongation of the cord is sufficient to significantly change the mass per unit length. If it does have an effect, take the appropriate measurements so that the correct mass per unit length may be computed.
7. For each of your five standing waves, calculate the tension, T, in the cord. Compute the predicted velocity from equation 2 using the tension and the mass per unit length of the cord found in step 6. Compare this velocity with the average velocity obtained in part 5.
8. In your report show diagrams of the standing waves observed.