Physics 110 **Spring 2008**

Union College
Transverse Standing Waves

Introduction:

When an object travels it carries along energy and momentum, because it has mass. In a traveling wave energy and momentum are made to travel in space, in the absence of transmission of any mass. This is because in wave motion it is the "disturbance" that moves. But like objects (particles) waves exhibit many physical phenomena such as transmission, reflection, energy loss, etc. They also exhibit phenomena very different from particles. One of these is interference: two waves that travel in opposite directions pass through each other so that at every point in space the net disturbance is an effective sum of their individual disturbances.

In this laboratory we will study two examples of standing waves, waves created when two traveling waves interfere in just the right way ("resonance") to produce a stationary pattern of nodes (places of zero wave disturbance) and antinodes (places of maximal disturbance.) The two examples are standing **transverse** waves on a string and standing **longitudinal** waves formed in a column of air driven by a small acoustic speaker.

For a one dimensional system we will study in this lab, a simple relation exists among the distance between successive nodes, the frequency of the driving mechanism, and the speed of wave propagation in the medium of interest:

$$v_{\text{wave}} = \lambda f \qquad (1)$$

where v_{wave} is the wave propagation speed, λ is the wavelength of the standing wave (which equals twice the distance between successive nodes, why?), and f is the (resonant) frequency of the standing wave.

<u>Transverse waves on a string</u>

- Set up the elastic string with a 250 g mass hung over the pulley and measure and record the length (with uncertainty) of string between the two fixed nodes (that at the pulley and that at the mechanical oscillator). Carefully adjust the frequency of the driver so that resonances are formed with 1 to at least 7 loops. Record the frequencies (make two measurements at each resonance and report the average- half the difference of your two independent measurements is an estimate of the uncertainty) and sketch the loop structure in each case. Are the resonant frequencies equally spaced? [Note: The fact that the smallest division on the meter stick is 1 mm does not necessarily mean that the uncertainty is 1 mm. Estimate for yourself how accurately you can measure the distance taking account of all the circumstances.]

- Plot the resonant frequency versus $1/\lambda$ and determine the velocity (with uncertainty) of the wave. The wave velocity can also be found from the equation

$$v_{wave} = \sqrt{F_T/\mu} \qquad (2)$$

  where F_T is the tension in the string and μ is the linear mass density of the string (mass/length). Measure μ, and then compute a velocity from Eq. 2 (with uncertainty), and compare your two values of the velocity.