Supplement for Physics 1415 Experiment 11
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Refer to "Introduction to Physical Science, Laboratory Guide" by Shipman, Wilson, & Todd
Amends Resonance Tube Procedure from p. 76 to top of p. 78.

5. When waves exist in or on the same object, they can interfere with one another. In *constructive interference*, the amplitudes of two waves add together to give a wave of larger amplitude. In *destructive interference*, the amplitudes of two waves act against one another to give a wave of a smaller amplitude.

We can observe interference by vibrating a string under tension at a constant frequency. You will use the apparatus provided to do so. It consists of a string extending over a pulley where a mass of ____________ grams is hanging (the instructor will provide this). This provides the tension (force) in the string. The mechanical oscillator at the other end causes the vibrations in the string. It is attached to a device called a function generator that creates electrical oscillations that make the mechanical oscillator vibrate. You will be adjusting the frequency on this device to change the frequency of vibrations in the string. A vibration from the oscillator travels along the string until it reaches the pulley where it bounces back toward the oscillator. We then have two waves traveling in opposite directions that can interfere.

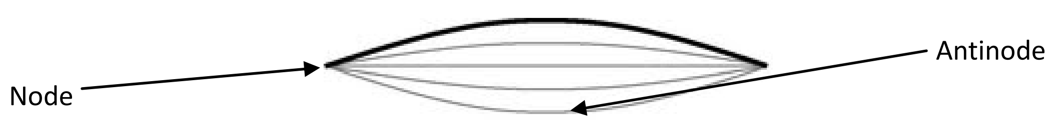
The wavelength of a wave caused by the oscillator is determined by the speed of the waves and the frequency of vibration as shown in the introduction. The speed of a wave on a string under tension is given in Part 2 of the procedure. We can already find the force on the string, but we still need the mass per unit length. Cut a 1 meter length of string, and use the precision balance to find its mass. Record the mass per unit length below.

Force on string (F) = (mass of hanger in kg) * (9.81 m/s2) = _______________

Mass per unit length (m/L) = mass of 1 m of string / 1 m = _______________

Speed of waves on string (v) = $\sqrt{\frac{F}{m/L}}$ = _______________

We want to produce what is called a standing wave. It occurs when the reflected wave constructively interferes with the outgoing wave. For this to occur, the wavelength of the waves must be such that there is a *node* (a location of minimum displacement where the string is always stationary in a standing wave) where the string contacts the pulley. Looking at Fig. 11.5 of a wavelength (λ) on page 75, we see that these are always separated by ½ of wavelength. In between nodes will be locations of maximum displacement called *antinodes*, which are ¼ of a wavelength from nodes. For the string to support a standing wave, the reflected wave must have its antinodes and nodes correspond with those of the outgoing wave. When a standing wave is produced you will see something like below, called a *loop*, perhaps many of them.



Measure the distance from the oscillator to the point where the string touches the pulley and record this length below. Turn on the function generator, turn the amplitude up, and adjust the frequency on the function generator until you see as few loops as you can. Record the frequency and number of loops below. Now change the frequency on the function generator until you see more loops than you just did. Record this frequency and number of loops below as well. Repeat this one more time for a different number of loops.

Distance between oscillator and pulley (L) = ________________

Standing Wave 1

Frequency (f_1) = _________________

Number of loops (N_1) = _________________

Standing Wave 2

Frequency (f_2) = _________________

Number of loops (N_2) = _________________

Standing Wave 3

Frequency (f_3) = _________________

Number of loops (N_3) = _________________

If you only have one loop then there are only two nodes, and the entire distance L must be ½ wavelength. If you have N loops, than the distance L contains $N/2$ wavelengths. The ability to create standing waves of many different wavelengths in one system leads to *harmonics* (or *overtones*) in music. Using this, find the wavelengths of the waves in the standing waves you observed.

Standing Wave 1 Wavelength (λ_1) = $2L/N_1$=_______________

Standing Wave 2 Wavelength (λ_2) = $2L/N_2$=_______________

Standing Wave 3 Wavelength (λ_3) = $2L/N_3$=_______________

Let us now calculate the speed of the waves in these standing waves using the relation $v = \lambda f$:

Speed of waves for Standing Wave 1 = ________________

Speed of waves for Standing Wave 1 = ________________

Speed of waves for Standing Wave 1 = ________________

Average speed of waves from standing waves = _________________

Compare your average speed above to the speed you calculated from the hanging weight and mass per unit length of the string using percent difference.