

PHY152H1S – Practical 7: Waves

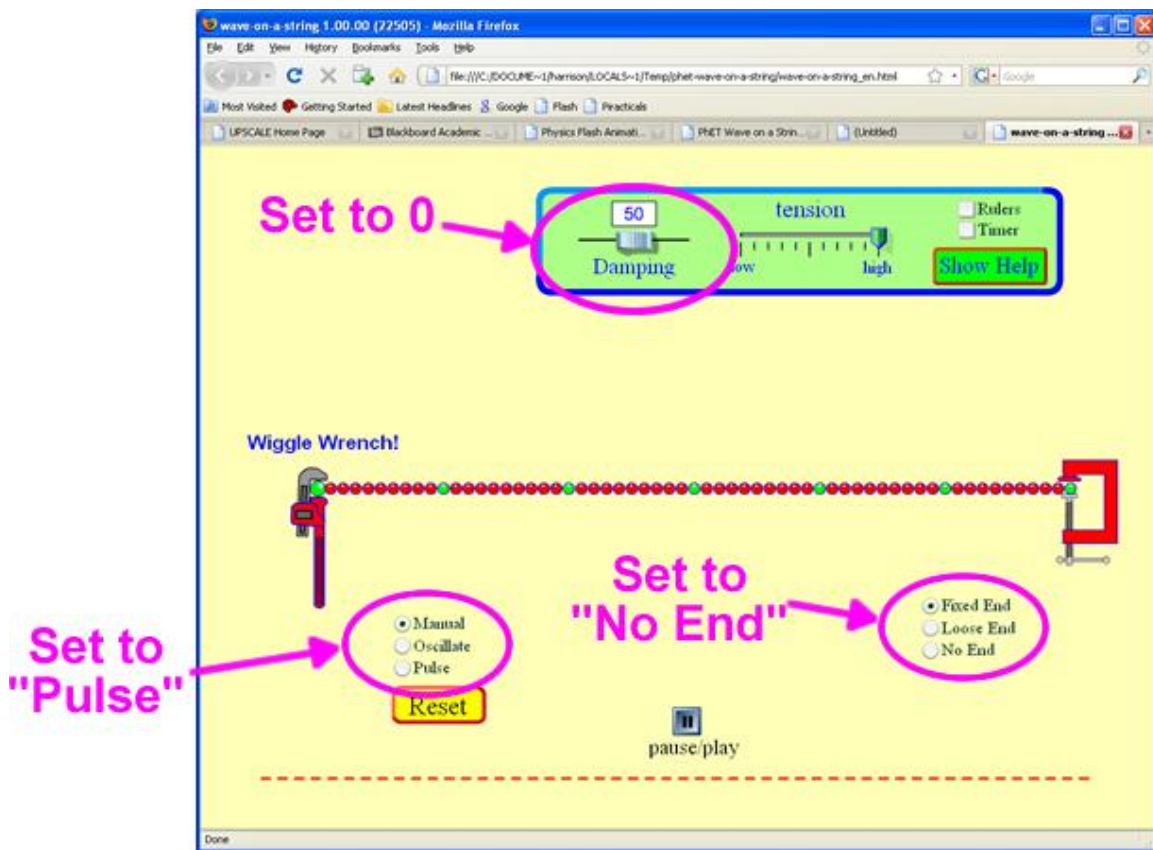
Don't forget:

- List the NAMES of all participants on the first page of each day's write-up. Note if any participants arrived late or left early.
- Put the DATE (including year!) at the top of every page in your notebook.
- NUMBER the pages in your notebook, in case you need to refer back to previous work.

Note that the activities below have numbers which refer to numbers in the Waves Module at <http://faraday.physics.utoronto.ca/Practicals/>.

Activity 1 (10 minutes)

- A. Open the Java applet `wave-on-a-string.jar` which is at `Feynman:Public/Modules/Waves`.



- Set the Damping to 0
- Set the wave type to “Pulse”
- Set the end to “No End” which will replace the vise on the right side with an open window for the waves to go through.

Click on the *Pulse* button that will appear. Imagine you are standing right beside the window as

the pulse goes out of it, measuring the amplitude as a function of time as it goes by you. Sketch the amplitude as a function of time.

- B. Click on the *Rulers* control in the upper-right corner of the simulation. The rulers that appear can be moved with the mouse. Estimate the speed, width and amplitude of the wave pulse. Add labeled tick marks on the axes of the sketch of Part A.

This is a good time to experiment with different values of the Damping and tension. What happens as the Damping is increased? What happens as the tension in the string is decreased? You may wish to explore some of the other settings of the simulation too.

Activity 5 (10 minutes)

- A. Open the Java applet `wave-on-a-string.jar` which is at:
`Feynman:Public/Modules/Waves`. Part A of Activity 1 shows a screen shot of the applet.
- Set the Damping to 0
 - Set the wave type to “Oscillate”
 - Set the end to “No End” which will replace the vise on the right side with an open window for the waves to go through.

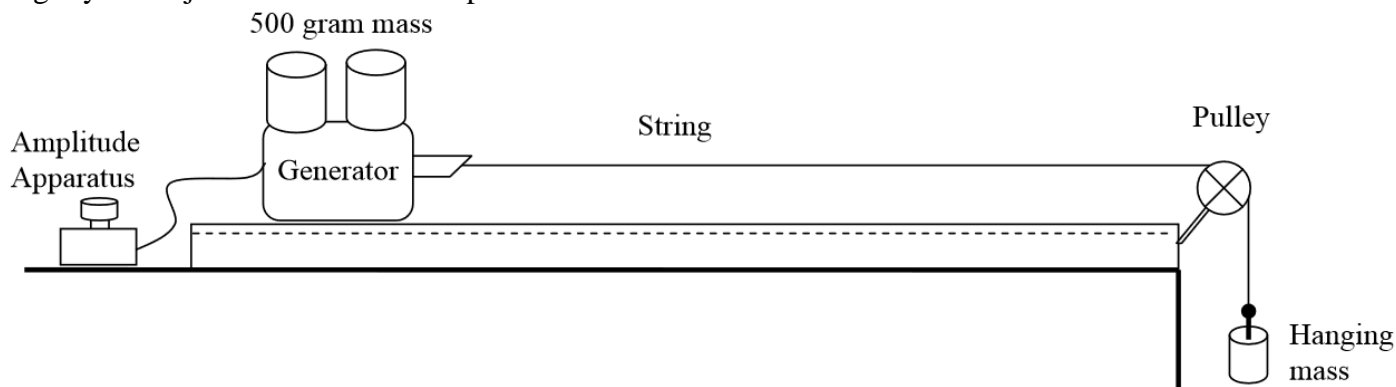
How does the amplitude of the wave change as it propagates down the string? Is this a one dimensional, two dimensional, or three dimensional wave? You may wish to look over Parts B and C before answering this question.

- B. A two dimensional wave, such as a water wave, is propagating away from its source equally in all directions. Assume damping is negligible. How does the amplitude of the wave change with distance from the source?
- C. A three dimensional wave, such as a sound wave, is propagating away from its source equally in all directions. Assume damping is negligible. How does the amplitude of the wave change with distance from the source?
- D. What physical principle or conservation law gives the answers to Parts A – C? Explain

Activity 11 (30 Minutes)

Open the ‘Vibrating String’ software package. The apparatus should be setup similar to the picture below. For this activity make sure to use the **nylon orange string**. Set the amplitude apparatus at maximum by turning the black knob on the grey box.

ATTENTION: When the vibrating metal bar starts hitting the edges making a noise, turn the amplitude slightly down just until the noise stops.



- A. Hang a 100 gram mass on the end of the string near the pulley and set the frequency to very low. (e.g. 5 to 10 Hz). Gradually increase the frequency until the amplitude of the wave changes dramatically indicating that you have reached a resonance (maximum amplitude). How does the amplitude change with the change in frequency (qualitative observation)? **(Make sure the TA agrees that you have found a resonance. The most common problem for this activity is difficulty in noticing a resonance.)**
- B. Make a table in your lab book similar to the one below. Find at least four resonances (maximum amplitude) in a closed-closed end standing wave pattern, starting from the first resonance, and measure the distances between consecutive nodes to fill in the first two columns of your table. Be sure to draw the shape of each standing wave in your notebook.

	Frequency (Hz)	Distance between nodes(m)	Wavelength (m)	Inverse frequency $1/f$ (s)
1				
2				
3				
4				

- C. Calculate the wavelength λ and inverse frequency ($1/f$) for each of the standing waves to complete the table in your lab notebook. Make a plot of λ versus ($1/f$). The slope should be the speed of waves on the string, and there should be zero intercept.
- D. Determine the mass density of the string by weighing it using the scale at the front of the room. Use this to calculate the predicted wave speed $v_{pred} = \sqrt{\frac{T}{\mu}}$. Compare the speed found above as slope of your graph to the predicted speed. Are they within errors? Why or why not?

Activity 12 (30 Minutes)

Open the ‘Vibrating String’ software package. The apparatus should be setup similar to Activity 11. For this activity make sure to use the **white/green fishing line**. Set the amplitude apparatus at maximum by turning the black knob on the grey box.

- A. Using hanging masses of 50 g, 100 g, 150g, vary the frequency to give a closed-closed end standing wave pattern. Make a table in your lab book similar to the one below.

Mass (kg)	Tension (N)	Freq (Hz)	Distance between nodes (m)	v (m/s)	v^2 (m^2/s^2)

- B. Make a plot of v^2 vs. T (where T is the Tension) from the results in your table. What is the physical meaning of the slope?
 C. How does your measured slope compare with the predicted value?

Activity 6 [If You Have Time]

- A. Open the Java applet `wave-on-a-string.jar` which is at:
`Feynman:Public/Modules/Waves`. Part A of Activity 1 shows a screen shot of the applet.
- Set the Damping to 0
 - Set the wave type to “Pulse”
 - Leave the end in its default state of “Fixed End” which clamps the right side of the string with a C-clamp.

Click on the *Pulse* button. What is the behavior of the wave pulse when it is reflected by a fixed end?

- B. Change the end of the string to “Loose End” which terminates the right hand side of the string with a frictionless loop around a vertical rod. Click on *Reset* and then on *Pulse*. What is the behavior of the wave pulse when it is reflected by a free end?
- C. Set the end of the string back to “Fixed End,” click on *Reset* and then on *Pulse*. Use the *pause/play* button and then the *step* one to step the wave pulse through a complete reflection at one end of the string. There is a point where the wave pulse nearly disappears. Where did the wave go? Where did the wave’s energy go? Explain what is happening.
- D. Set the end of the string back to “Loose End,” click on *Reset* and then on *Pulse*. Click on the *Rulers* control in the upper-right corner of the simulation. The rulers that appear can be moved with the mouse. Measure the maximum amplitude of the wave pulse; you may already have done this measurement in Activity 1 Part B. Use the *pause/play* button and then the *step* one to step the wave pulse through a complete reflection at one end of the string. There was a point where

the amplitude of the wave at the position of the free end was large. Use the ruler to estimate its amplitude. Explain your result.

- E. Set the end of the string back to “Fixed End.” Set the *Damping* to 10. Set the wave type to “Oscillate” and click on *Reset*. You will see a “standing wave” on the right hand side of the string. Use the *pause/play* button and then the *step* one to step the wave pulse through a complete reflection at the right end of the string. There is a point where the wave pulse near the right hand side nearly disappears. Where did the wave go? Explain what is happening.
- F. Set the end of the string back to “Loose End,” click on *Reset*. You will once again see a “standing wave” on the right hand side of the string. Is there a difference between this standing wave and the one you saw in Part E? Explain. Is there a point where the wave amplitude near the right hand side nearly disappears, as in Part E? Explain.
- G. Set the end of the string back to “Fixed End.” Leave the wave type as “Oscillate.” Set the *Damping* to 0. Click on *Reset*. What happens? Explain.

Although we have used the *wave on a string* applet in Activities 1, 5, and now here, there is still lots more Physics that you can learn from it. You are invited to explore further.

The Java applet used in Activities 1, 5 and 6 was written by the Physics Education Technology (PhET) group at the University of Colorado, <http://phet.colorado.edu/index.php>. Retrieved November 9, 2008.

The original Waves Student Guide was written by David M. Harrison, Dept. of Physics, Univ. of Toronto in the Fall of 2008. Activities 11 and 12 were written by Andrew Meyertholen in January 2014.

Last revision: March 4, 2014 by Jason J.B. Harlow.