Handouts for:
The Waves and Tsunamis Project

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Class Outline

The following notes were used by Ralph Stephen as an outline for his visits to 7th grade classrooms:

1) Introduction (7.5 minutes) - Talking with some powerpoint slides and answering questions.
  a) Who am I?
  b) What is WHOI?
  c) What do I do? Life at sea.
  d) Students should consider "scientist" as a career.
  e) Education required.

2) Waves (7.5 Minutes) - Talking with some powerpoint slides and answering questions.
  a) Why do we care about waves? What would life be like without waves?
  b) Types of waves.
  c) Tsunamis as an example of waves. Tsunamis have small amplitude (few centimeters) in the deep ocean but the amplitude grows in shallow water (10's of meters) and the waves "break".
  d) Waves transport energy without transporting mass.
  e) Wavelength, amplitude, period and frequency
  f) The Plymouth Wave Lab.

3) Introduction to the demonstrations of different wave phenomena at five stations. (5 minutes)

4) Students work with the five hand-on demos in small groups (about 5 minutes each). Written instructions with questions at each station.

Station Questions for the Waves and Tsunamis Project

This is a list of questions for the five stations in the "wave and tsunami class". The stations can be run through in any order.

1) Simple Harmonic Motion Stand - This station shows a mass bouncing on a spring. It demonstrates frequency and period. Pull the mass down and release it so that it bounces up and down. With a stop watch or your own wrist watch measure the time it takes (in seconds) for the mass to return each time to the bottom position. The time it takes for each cycle is called the <u>period</u>. Start the mass bouncing again and count how many times it hits bottom in a minute. This is the <u>frequency</u> in cycles per minute.

Period - P _______ seconds

Frequency - f _________ cycles per minute

[*Further work:* Convert the frequency to units of "cycles per second" by dividing the "cycles per minute" number by 60. Why? Then take the reciprocal of f (1/f). Compare this to the period.

Frequency - f _________ cycles per second

Reciprocal frequency - 1/f ___________ seconds per cycle

Note: The unit of frequency is usually cycles per second. This unit is called Hertz (or Hz for short). The period should equal the reciprocal frequency. Does yours?]

2) Small Wave Tank - This tank contains a layer of (clear) lamp oil over a layer of (green) water. By tilting the tank slowly back and forth you can generate small amplitude waves that travel back and forth on the surface of the oil and at the interface between the oil and the water. These are like <u>the wind-driven waves</u> on the ocean far from the beach.

How do the waves that hit the beach differ from the waves that are farther offshore?

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[*Further work:* Are the wavelengths of the waves at the surface of the (clear) oil the same as at the interface between the oil and the (green) water? If not, how do they differ?]

3) **Slinky -** Stretch the slinky out on the floor. Stop all motion on the slinky. Move one end side-ways to generate a transverse wave. Measure how long it takes for the transverse wave to reach the end of the slinky. Stop all motion on the slinky. Compress the coils at one end of the slinky and release them quickly to generate a compressional wave. Measure how long it takes for the compressional wave to reach the end of the slinky.

Time for transverse wave - _______ seconds

Time for compressional wave - _________ seconds

Which type of wave travels fastest on a slinky - transverse or compressional?

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4) Elastic Bands and Washers - Equal Weights - (See instructions below) Two students stretch the elastic band between them hanging in the air. On this string, the same number of washers has been added at each joint between the elastic bands. One student - the receiver - holds the cord steady at his/her end. The other student - the source - flicks his/her end to send a transverse traveling wave down the string. The other student(s) should stand back from the string so that they can see the wave travel down the whole string. How does the amplitude of the wave change as it travels down the string?

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[Further work: Can you excite a standing wave? How?]

5) Elastic Bands and Washers - Tapered Weights - (See instructions below) Two students stretch the elastic band between them hanging in the air. On this string, a different number of washers has been added at each joint between the elastic bands. The mass of the string gets less towards the end with the cord. One student - the receiver - holds the cord steady at his/her end. One student - the source - flicks his/her end to send a transverse traveling wave down the string. The other student(s) should stand back from the string so that they can see the wave travel down the whole string. How does the amplitude of the wave change as it travels down the string?

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[Further work: How does the amplitude behavior of the two elastic band demonstrations - uniform and tapered - differ?)

6) The Plymouth Wave Lab - This is a computer simulation of waves on a string. The instructor will show some examples in class, and then you can go to the web site below to see other examples on your own. Below are snapshots at two different times (0.25sec and 1.15sec) of a pulse wave traveling down a tapered string (like a whip, Example #3). Measure the amplitude and wavelength of the pulse at each time (units of inches or centimeters are fine).

Amplitude at 0.25sec. ____________________

Wavelength at 0.25sec ____________________

Amplitude at 1.15sec ____________________

Wavelength at 1.15sec ____________________

How do the amplitude and wavelength change as the string gets smaller?
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[Further work: How is this like a tsunami?
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How is this like a whip? ____

You can study these and other examples of waves on a string on the web at http://msg.whoi.edu/String_Lab/New_String_Movies.html .]

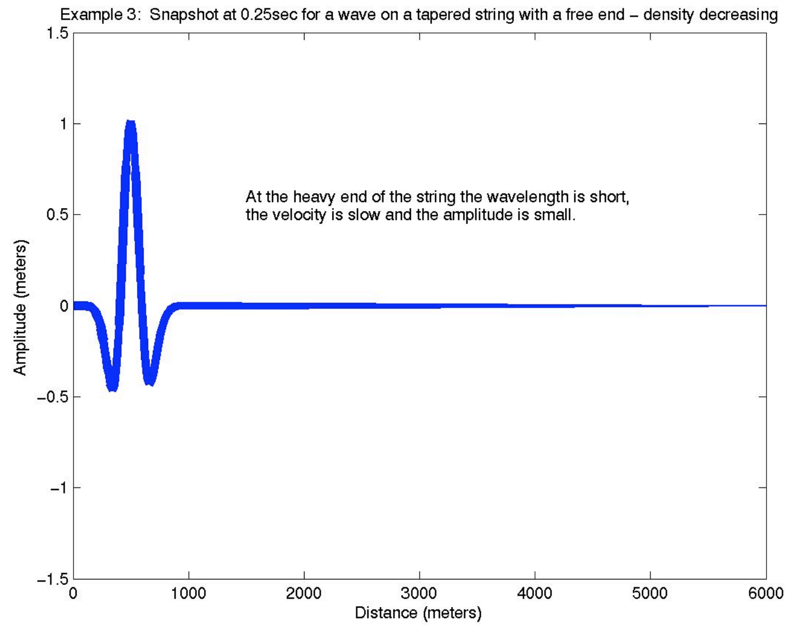

Figure 1: Snapshot at 0.25sec.

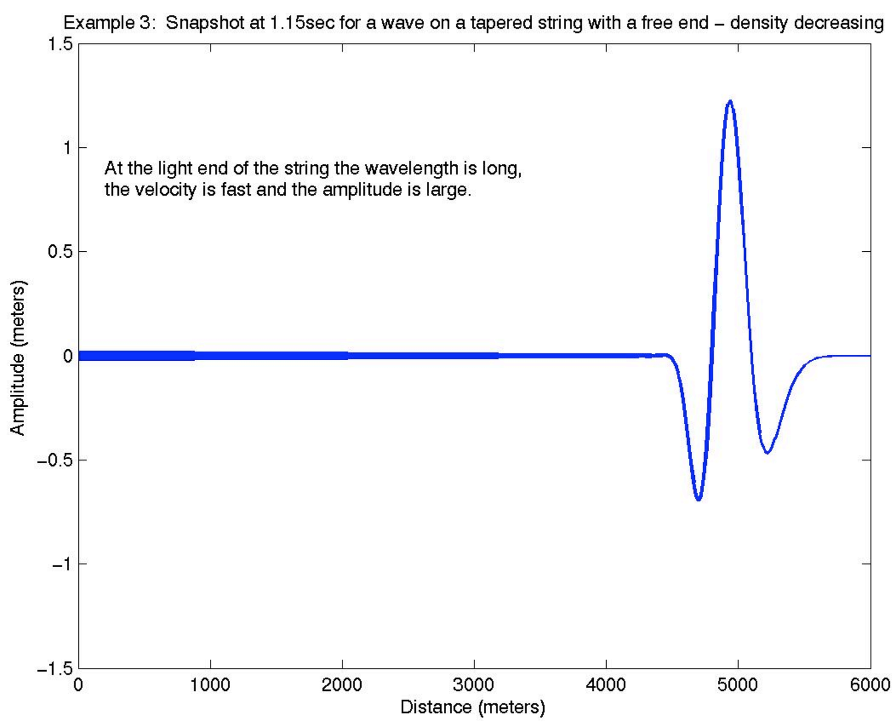

Figure 2: Snapshot at 1.15 sec.

Instructions for Making Strings from Elastic Bands and Washers

An inexpensive "string" can be assembled from elastic bands linked together with small washers placed at the intersections of the elastic bands. For example, a uniform string can be assembled with five washers at each junction of the elastic bands. A tapered string can be assembled by starting with one washer at the first four junctions, two washers at the next four, and so on. These notes describe how to make two strings, one uniform and one tapered. Materials are available at office supply stores and hardware stores and can be purchased for about $20.

Materials:
1lb. - #32 rubber bands (3"x1/8")
500 - 2" paper clips (vinyl coated in six colors are nice)
1 roll - drafting or masking tape
400 - #10 (3/16") steel, flat washers
6ft of string

Procedure:
1) Identify 10 "volunteers" and 4 "assistants". The assistants pass out materials and the volunteers assemble the string. It is easiest if the ten volunteers are standing in a line. Ask the volunteers to number off from 1 thru 10 and to remember their number.

2) Ask Assistant #1 to give four paper clips to each volunteer. (It is nice if different colors are given to adjacent volunteers. For example, if you have six colors give one color each to the first six volunteers and then start the color scheme over again for volunteers 7 thru 10.)

3) For the uniform string, ask Assistant #2 to give twenty washers to each volunteer. Then the volunteers attach five washers each to each paper clip by sliding the washers over the arms of the paper clips until they are in the middle of the paper clip. For the tapered string, ask Assistant #2 to give each volunteer four times their number of washers. For example, volunteer #1 gets 4 washers, volunteer #2 gets 8 washers, and so on. Then the volunteers attach one quarter of their washers to each paper clip. Volunteer #1's paper clips get one washer each, volunteer #2's paper clips get two washers each, and so on.

4) Ask Assistant #3 to give four rubber bands to each volunteer. Each volunteer should now assemble mini-strings consisting of paper clips and rubber bands alternately. This can be done by looping an elastic band around each end of a paper clip.

5) The volunteers now attach their mini-strings together to form a string of alternating elastic bands and paper clips.

6) Assistant #4 gives each volunteer four 1" to1-1/2" pieces of drafting tape. The volunteers wrap the tape around the paper clips to hold the washers in place. Ask volunteer #1 to attach the 6ft string to his/her end of the string.

7) The string is about 10 feet long so you need plenty of room. Ask Volunteers #1 and #10 to pull the string until it is off the floor and reasonably tight. Volunteer #1 is the fixed end and should hold the end of the string. Volunteer #10 is the "source" and should flick the end of the string to send a traveling wave down the string. Usually only a few tries are needed to get the speed and amplitude of the flick large enough to have the traveling wave propagate down the length of the string. It is interesting to compare the amplitudes and speed of the propagating wave between the uniform and tapered strings.