3: PROPERTIES OF WAVES

INTRODUCTION

Your ear is a complicated device that is designed to detect variations in the pressure of the air at your eardrum. The reason this is so useful is that disturbances in the air travel out in all directions as sound pressure waves. If someone slams a door in the next room, the disturbance in pressure travels through the air and soon reaches your ear. Sound waves travel very fast, so even if a car is coming your way at 70 mph, the sound made by the car will probably get to you in time for you to get out of the way.

The first lab introduced you to the way different types of vibrations are perceived as sound. This lab will introduce you to the way sound travels through the air, as a wave. Most of the rest of the semester will be spent examining these two aspects of physical sound in considerably greater detail.

In general, a wave is a disturbance traveling in a medium. If the disturbance is perpendicular to the direction of wave propagation the wave is called transverse, if the disturbance in along the direction of wave propagation – the wave is called longitudinal.

SMALL GROUP ACTIVITIES WITH SLINKIES

Several basic properties of wave behavior can be demonstrated with long springs and slinkies. We will do many of our experiments with springs and strings because you can see the waves on a spring, which you can’t do with sound waves. Your study of sound will be easier for you if you can learn to make analogies to other kinds of waves that you can visualize.

A) Wave Propagation and Reflection

1. Have one person hold one end of the spring and another person hold the other end. Stretch the spring until it is 15 ft long (square tiles in the hallway are 1ft on 1ft). One person should send pulses down the spring by jerking the spring to the right and back to center. Do these two motions very fast, to make the pulse as short as possible, but try not to overshoot when you bring your hand back to the center. The pulse should be only on one side:

   This

   Not This

Be sure that you understand why this is a wave which you are creating:
a) What is the medium in this case?

b) What is the disturbance?

c) Is the wave transverse or longitudinal?

All waves have the property that they can be reflected from boundaries. Waves are reflected different ways from different types of boundaries.

d) What happens to the pulses when they are reflected from the fixed end?

B) Speed of a Wave

Many important properties of sound depend on the speed at which it travels through the air, so it is important that you know what speed is and how to calculate it.

Speed is the distance something moves in one unit of time. The easiest way to measure speed is to measure the time it takes it to travel a known distance and then divide the distance by the time. Speed = distance/time.

1. Have a third person use a stopwatch to measure the amount of time it takes for a pulse to go down and back once. It may take several tries to get a good value for the time. Calculate the speed of the wave. Remember, distance = 30 ft! (15 down, 15 back.)

   a) How far does this wave travel in one second?

   b) How far would it travel in 15 seconds?

C) Wave Speed Depends on the Medium

1. Stretch the spring out to 20 ft., and once again send pulses down the spring.

   a) From casual observation, does the pulse travel faster or slower than before?

   b) Measure the speed with the watch:
D) Is there Reflection from a Free End?

1. Tie a long string (10 ft. or more) to the end of the spring.

Before you send pulses down the spring, predict what will happen to the pulses when they hit the string. Will they be reflected, or disappear, or do something else? (The spring/string junction is called a “free end” because the string allows the spring back and forth freely. Since this is a transverse wave, only the back-and-forth direction matters as far as the wave is concerned.)

a) Now try it. What happens?

b) Draw sketches showing how this is the same or different from when the wave hit the fixed end.

E) Longitudinal Waves on a Slinky

Coil the long spring neatly in the box and get out the slinky. Most demonstrations work better with the slinky if you only use half of its length, so have the person who holds the fixed end keep half of the slinky all bunched up in his or her hands. Stretch the remaining half of the slinky until it is about 10 ft long.

The slinky is useful because you can use it to make both transverse and longitudinal waves. First, make a couple of transverse waves in the same way you did with the long spring.

1. Now try making longitudinal waves (waves in which the disturbance is in the same direction as the direction of propagation): thrust your hand suddenly toward the person holding the fixed end and then back to its starting point. Do this as quickly as possible, but try not to get any side to side motion. Watch the compression pulse move down the slinky. This is analogous to a region of high pressure moving as a sound pulse in the air; sound waves are longitudinal.
Longitudinal waves are also called “compression-rarefaction waves.” Regions where the medium is all bunched together are called regions of compression, whereas places where the medium is a spread out are called regions of rarefaction. In air this corresponds to regions of high and low pressure.

2. If you are careful, you can see a pure rarefaction pulse moving along the slinky. To do this, let out the entire slinky and stretch it to that it covers only 8 ft. Now suddenly jerk your hand away from the person holding the fixed end but do not return it to its original position until the wave has died out.

3. If you push the slinky back and forth you have alternating regions of high and low pressure, like a continuous sound wave in the air. Sketch a longitudinal pulse propagating along the slinky.