Understanding Waves Student Lab Sheet

Objective: To understand transverse and longitudinal waves and the characteristics of frequency, wavelength, and interference.

Materials: Double length slinky, rope, or other type of spring

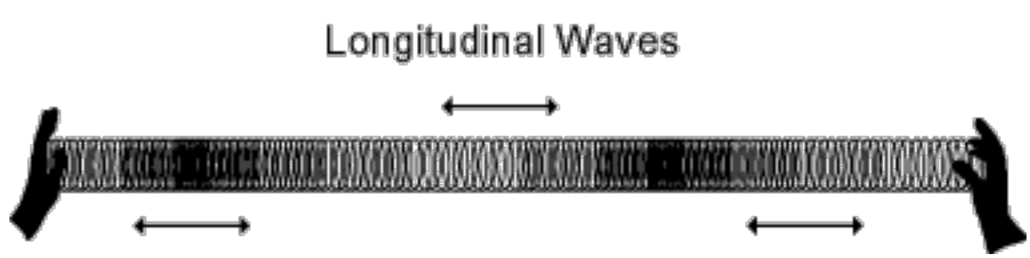
Introduction: A wave is an oscillating, repetitive motion that travels through matter or space. They are all around us -water waves, sound waves, microwaves, and radio waves...just to name a few. Waves (except for light waves) need to travel through some sort of medium, such as a solid, liquid, or gas. These media transfer the wave energy. In a wave on the ocean, water is the medium. For a sound wave, air is the medium.

There are two classes of waves, transverse and longitudinal. A transverse wave is one in which the medium moves perpendicular to the wave direction. Transverse waves cause the medium to move up and down while the wave moves out from its source. An example is an ocean wave. A longitudinal wave, sometimes called a compressional wave, moves in the same direction as the medium. An example is a sound wave. Many waves move too fast or are too small to watch easily. But in a long "soft " spring, you can make big waves that move slowly.

Procedure: The experiments described below are best done in groups of 3 students: one serves as the "shaker ", one as the "holder " and one as the "observer/recorder ". Over the course of the experiments, students should rotate through each of the roles.

I. Longitudinal Waves

With a partner to help you, pull the spring out on a smooth floor to a length of about 6 to 10 meters. With your free hand, grasp the stretched spring about a meter from one end. Pull the meter of spring together toward yourself and then release it, being careful not to let go of the fixed end with your other hand! Notice the single wave, called a pulse, travel along the spring. In such a longitudinal pulse, the spring coils move back and forth along the same direction as the wave travels. The wave carries energy, but the spring remains stationary after the pulse has passed through it and reflected from the other end.



1. What kinds of waves travel as longitudinal pulses?

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2. What happens to the energy?

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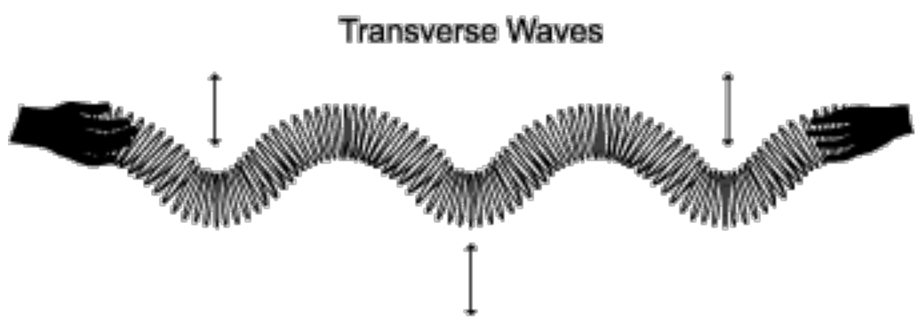
Note: You can see a longitudinal wave more easily if you tie pieces of string to several of the loops of the spring and watch their motion when the spring is pulsed.

II. Transverse Waves

A transverse wave is easier to see. To make one, practice moving your hand very quickly back and forth at right angles to the stretched spring until you can produce a pulse that travels down only one side of the spring (that is, the bump on the spring due to the pulse is only on the right or left side of the spring). This pulse is called "transverse " because the individual coils of wire move at right angles to (transverse to) the length of the spring.



Perform experiments to answer the following questions about transverse pulses.

3.Does the size of the pulse change as it travels along the spring? If so, in what way?

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4.Does the pulse reflected from the far end return to you on the same side of the spring as the original or on the opposite side? Does the wave have the same size?

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5.Does a change in the tension of the spring have any effect on the speed of the pulses? When you stretch the spring farther, you are changing the nature of the medium through which the pulses move.

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5A. Solids carry sound waves much faster than air. Using your answer in #5, develop a hypothesis (guess) about why solids carry sound faster than gasses

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Next observe what happens when waves go from one material into another -an effect called **refraction**. Attach a length of rope or rubber tubing (or a different kind of spring) to one end of your spring and have your partner hold the end of it.

6. What happens to the pulse when it reaches the boundary between the two media? Describe its size, shape, speed, and direction in BOTH media after the pulse reaches the boundary. Notice that the far end of your spring should now be free to move back and forth at the joint, which it was unable to do before because your partner was holding it. If you notice that the far end of the spring is not moving freely, be sure to make a note of it in your observations as you record the answer to this question.

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Have your partner detach the extra spring and once more grasp the far end of your original spring. Have him send a pulse on the same side at the same instant you do, so that the two pulses meet. The interaction of the two pulses is called **interference.**

7.What happens when the two pulses reach the center of the spring? Describe the size, shape, speed and direction of each pulse during and after the interaction. It will be easier to see what happens in the interaction if one pulse is larger than the other.

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8.What happens when two pulses on opposite sides of the spring meet? That is, send one down the right side and have your partner send another down the left side at the same time. Describe as in question 7.

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9.As the two pulses pass each other when they started on opposite sides of the spring, can you observe a point on the spring that does not move at all? Explain.

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10.From the observations you made in questions 7 -9, make a general statement about the displacement caused by the addition of two pulses at the same point.

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By vibrating your hand steadily back and forth, you can produce a train of pulses, or a periodic wave. The distance between any two neighboring crests on such a periodic wave is the wavelength. The rate at which you vibrate the spring will determine the frequency of the periodic wave. Produce various short bursts of periodic waves so that you can answer the following question.

11.How does the wavelength depend on the frequency?

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References:
• Harvard Project Physics
• Modern Laboratory Experiments in Physics, Brinckerhoff and Taft
• Investigations in Science: Light and Sound, Phil Parratore, Creative Teaching Press, 1996