ACTIVITY #3 WAVE AT ME (TEACHER NOTES)

This activity addresses the following content standards and benchmarks[1]:

- Content Standard 5 – 8 Physical Science B Transfer of Energy
- Content Standard 9 – 12 Physical Science B Interaction of Energy and Matter
- Benchmark 6 – 8 and 9 –12 The Physical Setting 4F Motion

Students are encouraged to classify pulses and waves according to several criteria. The first type of classification concerns the direction of the disturbance compared to the direction of propagation of the wave. Emphasize that in transverse waves, the individual particles of the medium move perpendicular to the direction of propagation of the wave, whereas in longitudinal waves, the individual particles move parallel to the direction of propagation of the wave (but not the whole length of the wave's path). Have students reflect back to Activity #1 Human Body Wave. The longitudinal disturbance was the gentle sideways push and the transverse pulse was the raising of the hands overhead.

The relative speed of the longitudinal pulse is faster than that of the transverse pulse because the particle interactions at the atomic level of the medium transferring the energy. A longitudinal wave involves a direct collision of one atom with another (or in the case of solid bonding, the shortening of the bond between two atoms which displaces the second atom in a direction that shortens the next bond); whereas a transverse wave involves transferring a motion perpendicular to the bond which then displaces the second atom perpendicular to its bond etc. This is a weaker and slower process hence the wave propagates slower. As illustrated in Activity #1, "Human Wave" can demonstrate this. Line up a group of students shoulder to shoulder and have them put their arms around each other's waists or shoulders to simulate bonds. Push on the first students shoulder in the direction of the line to simulate a longitudinal wave. Then bend the first student up and down as if bowing to simulate a transverse wave. The longitudinal wave will travel slightly faster. If the students put their arms at their sides, only the longitudinal wave will propagate showing that transverse waves do not travel through liquids e.g., the earth's core. Loosening their grip on each other to simulate softer materials will slow down the transverse wave.

As a quick evaluation of the conceptual difference between a longitudinal disturbance and a transverse disturbance, suspend a ping-pong ball at the end of a laboratory table so that the ball just rests against the edge of the table. Have a student strike the opposite end of the tabletop perpendicular to the surface (transverse) and examine the motion of the ping-pong ball. Repeat the process by striking the end of the tabletop parallel to the surface (longitudinal) and examine the motion of the ball. Students should be able to identify the longitudinal blow as producing a greater motion of the ping-pong ball. One reason might be that the tabletop will vibrate parallel to the plane of the table, transferring more of the energy of the blow to the ball. Another might be that it is difficult for the ball to vibrate vertically since gravity pulls it downward equal to than the tension force from the string. This is a good topic to allow students to speculate and create their own reasons.

If you do not have a slinky™, you can have students make the speed measurements using the video you can find at http://paer.rutgers.edu/PT3/experiment.php?topicid=6&exptid=66. This video also illustrates the technique for making and timing waves. To run the video double click on it.

Use the Cinema Classics –C Waves I Title I Chapter 2 to define a wavelength of a transverse wave and Title II Chapters 6 – 10 to examine the transference of energy via a transverse pulse. A transverse pulse is sent long a slinky™ that is stretched along a bowling alley with a pin at the far end of the alley. A

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[1] National Science Education Standards, National Research Council, 1996

transverse pulse literally bowls over a pin. Title 5 Chapters 1 – 3 identify the compression and the rarefaction of a longitudinal wave using a slinky™ suspended via strings horizontally.

Physlet Illustration 17.1 "Wave Types" reinforces for students the differences between longitudinal and transverse pulses and traveling waves and introduces the water wave, a mechanical wave that is the combination of longitudinal and transverse waveforms. Physlet Exploration 7.2 "Measure the Properties of Waves" allows students to measure the relevant properties of a wave and use these properties in the wave function formula. The properties of the wave can be examined without the mathematical rigor.

Answers to questions within the laboratory activity:

1. **What happens to the shape of the pulse as it travels down the spring?**
   Answer: The pulse maintains its wavelength and general shape, but loses some of its amplitude.

Look up and record the name of this type of wave motion. *Answer: Longitudinal*

Give another example of this type of wave motion. *Answer: Sound waves and Seismic P waves*

2. Look up and record the name of this type of wave motion. *Answer: Transverse*

Give another example of this type of wave motion. *Answer: Any electromagnetic wave (Radio, UV, etc.)*

How does the speed of a longitudinal wave (pinched coils) compare to the speed of a transverse wave (pulled to the side) for the same stretch? *Answer: Longitudinal waves travel faster than transverse waves because the restoring force is greater. The relative speed of the longitudinal pulse is faster than that of the transverse pulse because the particle interactions at the atomic level of the medium transferring the energy. A longitudinal wave involves a direct collision of one atom with another (or in the case of solid bonding, the shortening of the bond between two atoms which displaces the second atom in a direction that shortens the next bond); whereas a transverse wave involves transferring a motion perpendicular to the bond which then displaces the second atom perpendicular to its bond etc. This is a weaker and slower process hence the wave propagates slower.*

3. **How do the coils in a longitudinal pulse move relative to the direction in which the wave is traveling?** *Answer: In a longitudinal wave the particles of the medium oscillate or vibrate in a direction parallel to the direction that the wave travels.*

   How do the coils in a transverse pulse move relative to the direction in which the wave is traveling? *Answer: In a transverse wave the particles of the medium oscillate or vibrate in a direction that is perpendicular to the direction that the wave travels.*

   Based on the above descriptions, suggest a reason why different pulses travel with different speed? *Answer: Longitudinal waves travel faster than transverse waves because the restoring force is greater. The relative speed of the longitudinal pulse is faster than that of the transverse pulse because the particle interactions at the atomic level of the medium transferring the energy. A longitudinal wave involves a direct collision of one atom with another (or in the case of solid bonding, the shortening of the bond between two atoms which displaces the second atom in a direction that shortens the next bond); whereas a transverse wave involves transferring a motion perpendicular to the bond which then displaces the second atom perpendicular to its bond etc. This is a weaker and slower process hence the wave propagates slower.*