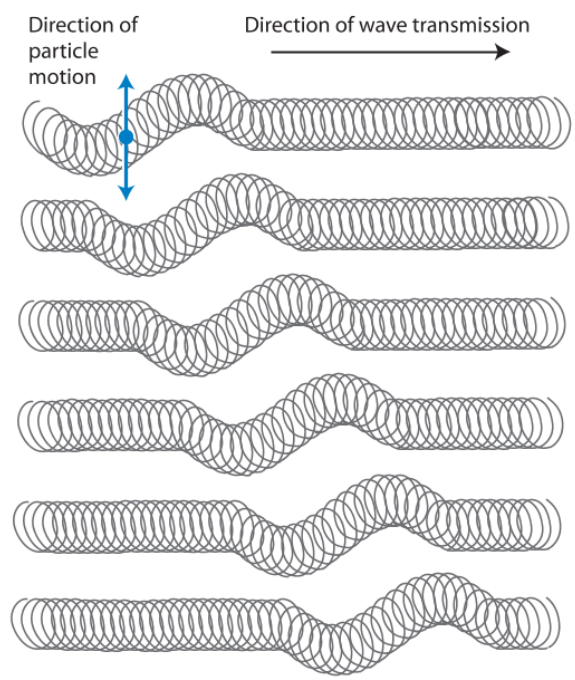
7 Another Kind Of Wave

INVESTIGATION

SOUND IS ONE of many kinds of waves. Other common waves include those on the surface of water, light waves, radio waves, and seismic waves. Digital sound transmission, as described in the last activity, involves more than one kind of wave. For example, a sound wave could be transformed into a microwave for transmission. When it arrives at its destination, the digital information encoded on the microwave is reconstructed back into the sound wave.

All waves share some of the same characteristics, but they also differ in certain ways. A good example of this becomes apparent when comparing sound and light. As with all waves, sound and light both carry energy. Like sound, light is an integral part of our everyday life. However, there are important differences. One difference is that light travels over 800,000 times faster in air than does sound. Another difference is that light is not a longitudinal wave like sound but, instead, behaves as a transverse wave. A **transverse** wave consists of vibrations that are perpendicular to the direction that the energy travels. A transverse wave may travel through a medium, such as secondary waves (s-waves) in an earthquake, or without a medium, such as light through a vacuum. This means that a transverse wave does not have compressions and rarefactions like sound. In this activity, you will model the characteristics of transverse waves using a long metal spring.



Transverse wave

GUIDING QUESTION

What are the characteristics of a transverse wave?

MATERIALS

For each group of four students

1 long metal spring

For each student

1 pair of safety goggles

1 sheet of graph paper

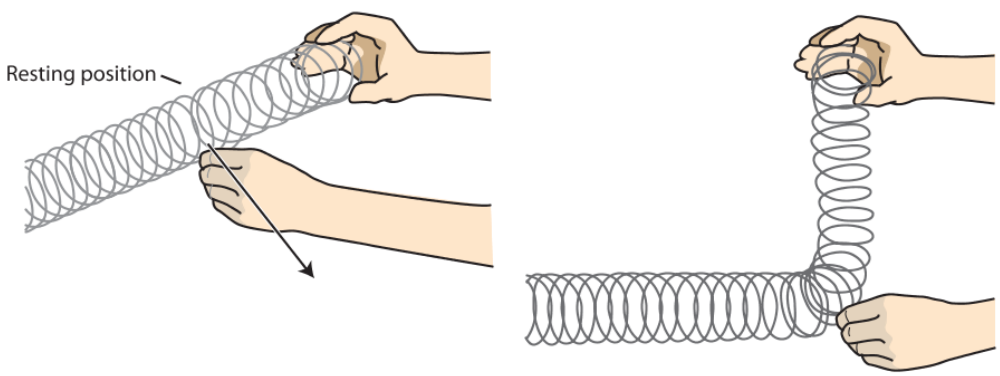
SAFETY

Handle the springs with care and never let go suddenly when the spring is under tension. If released when tension is being applied, the spring can move rapidly and unpredictably and could scratch someone. Wear safety goggles to protect your eyes from such an event.

PROCEDURE

Part A: Wave Pulses

1. Put the spring on the floor or a long table, holding the ends about 2 m apart.
2. Near one end of the spring, pull a coil away from its resting position toward one side of the spring, as shown below. When everyone is ready, release the coil to make a wave pulse.

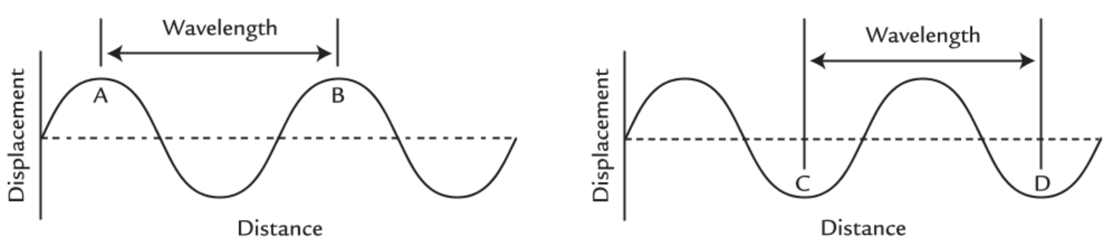


3. All group members should observe the pulse as it travels down the spring.
4. Record the group's observations in your science notebook.
5. Create additional pulses by pulling and releasing more coils. Each time, observe and record what happens as the pulse travels down the spring.

6. Predict what would happen if you pulled the coil farther from the resting position, or increased the amplitude, before releasing it.
7. Test your prediction and record the results in your science notebook. Draw and label two diagrams that show a comparison of the waves.
8. Describe any evidence you saw that the transferred energy increased when you increased the amplitude.
9. Change roles and repeat Steps 2–7 with the spring ends held about 4 m apart. Record any differences that you observe.

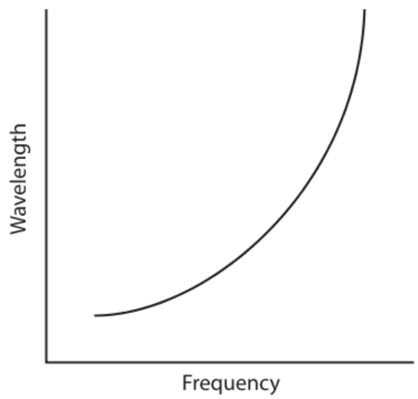
Part B: Transverse Waves

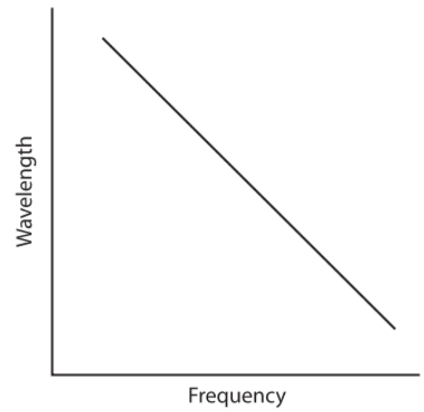
10. Generate a transverse wave instead of a single pulse by continuously moving one end of the spring to the left and right. Record your observations in your science notebook.
11. Vary the amplitude of the wave from small to large. All group members should observe and record what happens as the wave travels down the spring.
12. Vary the frequency of the wave from low to high. All group members should observe and record what happens as the wave travels down the spring.
13. Draw and label four diagrams that show a comparison of the waves from the previous two steps.
14. On one of your wave diagrams, label the wavelength. The **wavelength** of the wave is the length of one wave cycle, as shown in the diagrams below.



15. Repeat making a wave with a low frequency and compare it with one with a high frequency. Compare the wavelengths of the two waves as they travel down the spring.

16. Using what you observed in the previous step, draw two wave diagrams. In the first diagram, draw a wave with a low frequency. In the second diagram, draw a wave with a higher frequency. Label the frequencies and wavelengths in both diagrams.
17. In your group, discuss what you observed about the relationship between the frequency and wavelength. Decide which of the following graphs best describes what you observed and modeled in your diagrams.

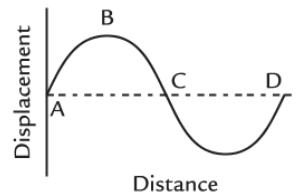




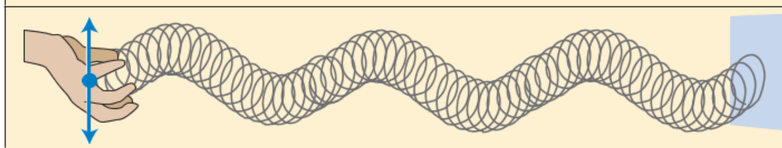
ANALYSIS

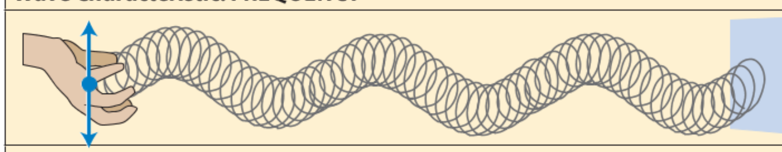
1. Describe what happened when
   a. the wave pulses reached the end of the spring.
   b. the transverse wave reached the end of the spring.
2. What happened when the spring was stretched to double its length?
3. What happened to the amplitude of the wave pulse when it traveled along the spring? Suggest an explanation for your observations.
4 Do you think that sound also has a wavelength? Explain why or why not.

5. Look at the diagram shown on the right of a wave made with a spring.
   a. Describe the motion of the spring at points B and C.
   b. Is the energy transfer of the wave parallel or perpendicular to the motion of the spring at point B? Explain.



6. Trace the diagram from the previous question above, and then
   a. draw what the wave would look like if the amplitude was doubled.
   b. draw what the wave would look like if the frequency was doubled.
   c. draw what the wave would look like if the wavelength was doubled.
7. Make two tables like the ones below, and fill in the missing diagrams to show changes in wavelength and frequency. Then explain what your diagrams model.

Wave Characteristic: WAVELENGTH

a. diagram of a wavelength increase
b. diagram of a wavelength decrease

Wave Characteristic: FREQUENCY

a. diagram of frequency decrease
b. diagram of frequency increase

8. For a wave of a given speed, what is the relationship between the wavelength and the frequency? Use your diagrams from the activity and the model from the previous item to look for patterns.

9. A transverse wave with constant speed has an increase in amplitude over time, as shown in the left-hand column of the table below. Some of the data for energy and wavelength is missing.

Transverse wave data		
Amplitude (m)	*Energy (J)*	*Wavelength (m)*
1	*10*	*0.3*
2	*40*	*0.3*
3	*90*	*0.3*
4		
5		

a. Look at the patterns in the data and predict the missing energies and wavelengths of the wave. In your science notebook, copy the last two rows of the table and complete the data. Then explain the pattern you followed to fill in the data.

b. Make a graph of amplitude (x-axis) vs. energy (y-axis) that includes all five times. Make sure to label your graph.

c. Use your graph to predict the energy and wavelength for the amplitude of 7 m.

EXTENSION

Investigate a *standing wave* and model them with your long spring.