Waves on a Helical Spring Teacher's Notes

Main Topic	Waves
Subtopic	Waves
Learning Level	Middle
Technology Level	Low
Activity Type	Student

Description: Students investigate properties of mechanical waves using a helical spring: wavelength, speed, reflection, standing waves, interference.

Required Equipment	Helical Spring, Stopwatch, String
Optional Equipment	

Educational Objectives

- Investigate properties of mechanical waves using a helical spring.

Concept Overview

Investigating Wave Speed: Students will observe that neither amplitude nor frequency affects wave speed. Only changing the tension of the spring (changing a property of the medium) can change the speed.

Wavelength and Frequency: Students will observe that as wave frequency goes up, wavelength goes down, and vice versa.

Interference of Waves: Students will observe that wave pulses can interfere constructively (adding together when on the same side of the spring) or destructively (canceling out when on opposite sides of the spring).

Waves at Boundaries: Waves will invert upon reflecting from a rigid boundary, but not from a flexible boundary. When a wave meets a similar medium, part of the wave will transmit and part will reflect. The transmitted wave will change length and speed. The reflected wave may invert or not, depending on the two media.

Standing Waves: The nodes of a standing wave may be touched without disturbing the wave. Touching an antinode will disrupt the wave.

Lab Tips

This lab is best done in a large or long area with a hard floor, such as a gym or hallway.

Waves on a Helical Spring

Name: ____________________

Class: ______________________

Pre-Lab Questions:

1. In a transverse wave, the particles of the medium vibrate ____ the direction of propagation of the wave.
   a. in the same direction as
   b. in a perpendicular direction to
2. List some waves that are transverse.
   ____
3. In a longitudinal wave, the particles of the medium vibrate ____ the direction of propagation of the wave.
   a. in the same direction as
   b. in a perpendicular direction to
4. List some waves that are longitudinal.
   ____

Goal:

Investigate properties of mechanical waves using a helical spring.

Materials:

Helical Spring, Stopwatch, String

Procedure:

1. Pace out an approximately-10-meter distance on the floor and mark it with small pieces of tape.
2. Stretch the spring between the marks, and shake one end back and forth several times to create a transverse wave. Draw a picture of your wave.
3. Shake the spring to create a longitudinal wave. Draw a picture of your wave.

Investigating Wave Speed

4. Generate a single back-and-forth transverse wave pulse. Estimate or measure the time it takes the pulse to travel 10 meters. Experiment with different sized pulses, and describe the effect of wave amplitude on wave speed.
5. Generate a traveling wave (several pulses together). Estimate or measure the time it takes the wave to travel 10 meters. Experiment with different wave frequencies, and describe the effect of wave frequency on wave speed.

 Name: ___________________
Class: ____________________

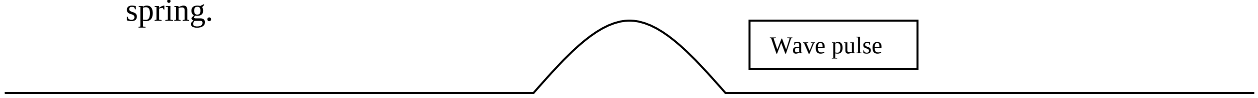
6. Stretch the spring more by gathering a few inches into your hand. Generate another single pulse. Estimate or measure the time it takes the pulse to travel 10 meters. Experiment with different spring tensions, and describe the effect of the properties of the medium on wave speed.

Wavelength and Frequency

7. Shake the spring back and forth repeatedly. Observe the length of the waves you generate. Shake the spring slowly, and then shake it quickly. Describe the relationship between wave frequency (high/low) and wavelength (long/short).

Interference of Waves

8. Now you will create single pulses at both ends of the spring, simultaneously. Practice so that you can create similar pulses on the left and right sides of the spring.



9. Generate two similar pulses, from opposite ends, on the same side of the spring. Describe the displacement of the spring at the point where the two pulses meet.

10. Generate two similar pulses, from opposite ends, on opposite sides of the spring. Describe the displacement of the spring at the point where the two pulses meet.

11. For both cases, what happens to the shape of the individual pulses after they meet in the middle?

Waves at Boundaries

12. Generate a pulse at one end of the spring while holding the other end absolutely still. Describe what happens to the pulse when it meets the rigid end.

13. Loop a piece of string (at least 2m long) through the "held" end of the spring, and hold the string. Generate a pulse while holding the other end by the length of string. Describe what happens to the pulse when it meets the mobile end.

14. Remove the string. Hold the end still again. Shake the spring slowly back and forth until you generate a standing wave with one node (still point) in the center of the spring.
15. Change the frequency so that there are 2 nodes. What happens when someone touches the spring with a pencil at one of the nodes?

16. What happens when someone touches the spring with a pencil at one of the antinodes?

17. What is the largest number of nodes you can create in a standing wave with this spring? Draw a picture of your standing wave.

18. (May be done as a demonstration.) Connect one end of the helical spring to a wider Slinky spring. Generate a pulse in the small spring while holding the other end of the Slinky. Describe what happens to the pulse when it meets the boundary of the two media. (Describe where the wave pulses went, what sizes they were, and what speeds they traveled.) Draw pictures of the springs before and after the pulse reached the boundary.