1. Two students, 5.0 m apart, each hold an end of a long spring. It takes 1.2 s for a pulse to travel from the student generating the pulse to the lab partner at the opposite end of the spring.
   a. How long will it take for the pulse to return to the “generator”?

   b. Explain the motion of the pulse passing through the spring. Calculate the speed of the pulse.

2. The “generator” in Problem 1 repeats the experiment with a pulse of twice the original amplitude. Will the pulse take more time, less time, or the same time to reach the far end of the spring? Explain your answer.

3. The students move so that they are now twice as far apart but use the same spring. How will the speed of the pulse sent now compare to the speed of the pulse sent when they were 5.0 m apart? Explain your answer.

4. Match the letters below to the corresponding terms which follow:
   - amplitude ____
   - equilibrium ____
   - transverse pulse ____
   - fixed end ____
   - pulse length ____
5. A pulse on a spring of the shape above is moving right toward A with a velocity $v$. Describe in detail the motion of coil A on the spring as the pulse goes by, causing coil A to move through positions 1-5. For each of the positions, be sure to indicate the direction of the motion of coil A (up, down or not moving), and state whether the velocity of coil A is increasing, decreasing, or zero.

<table>
<thead>
<tr>
<th>Number of position</th>
<th>Direction of Motion</th>
<th>Statement on velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
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<tr>
<td>3</td>
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<td>4</td>
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<tr>
<td>5</td>
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6. The graph below was produced by plotting data for the distance ($d$) a pulse traveled along a spring in time $t$. Write the mathematical model for the data graphed below.
7. A sound wave produced by a clock chime is heard 515 m away 1.50 s later.
   a. What is the speed of sound of the clock’s chime in air?
   b. The sound wave has a frequency of 436 Hz. What is the period of the wave?

8. A hiker shouts toward a vertical cliff 465 m away. The echo is heard 2.75 s later. What is the speed of sound of the hiker’s voice in air?

9. The Willis Tower in Chicago sways back and forth in the wind with a frequency of about 0.12 Hz. What is its period of vibration?

10. The speed of sound in water is 1498 m/s. A sonar signal is sent straight down from a ship at a point just below the water surface, and 1.80 s later, the reflected signal is detected. How deep is the water?

11. The velocity of the longitudinal waves produced by an earthquake is 8.9 km/s, and that of the transverse waves is 5.1 km/s. A seismograph records the arrival of the transverse waves 68 s before the arrival of the longitudinal waves. How far away is the earthquake?
1a. It will take an additional 1.2 s for the pulse to return therefore the total time is 2.4 s.

1b. \[ v = \frac{\Delta d}{\Delta t} \]
\[ v = \frac{5.0 \text{ m}}{1.2 \text{ s}} \]
\[ v = 4.2 \text{ m/s} \]

2. The speed of the pulse does not depend on the amplitude of the pulse therefore the time will remain the same.

3. As they move farther apart, they stretch the spring increasing the tension. As the tension increases so does the speed of the pulse.

4. amplitude - D
   equilibrium - B
   transverse pulse - A
   fixed end - E
   pulse length – C

5. | Number of position | Direction of Motion | Statement on velocity |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Up</td>
<td>Increasing up</td>
</tr>
<tr>
<td>2</td>
<td>Up</td>
<td>Not changing</td>
</tr>
<tr>
<td>3</td>
<td>Stopped</td>
<td>Changing direction</td>
</tr>
<tr>
<td>4</td>
<td>Down</td>
<td>Not changing</td>
</tr>
<tr>
<td>5</td>
<td>Down</td>
<td>Slowing</td>
</tr>
</tbody>
</table>

6. \[ d = \left( \frac{12.0 \text{ m}}{1.8 \text{ s}} \right) t \]
\[ d = (6.67 \text{ m/s}) t \]

7a. \[ v = \frac{\Delta d}{\Delta t} \]
\[ v = \frac{515 \text{ m}}{1.50 \text{ s}} \]
\[ v = 343 \text{ m/s} \]

7b. \[ T = \frac{1}{f} \]
\[ T = \frac{1}{436 \text{ Hz}} \]
\[ T = 0.00229 \text{ s} \]
8. \( v = \frac{\Delta d}{\Delta t} \)
\( v = \frac{465 \text{ m}}{1.375 \text{ s}} \)
\( v = \boxed{338 \text{ m/s}} \)

9. \( T = \frac{1}{f} \)
\( T = \frac{1}{0.12 \text{ Hz}} \)
\( T = 8.3 \text{ s} \)

10. \( v = \frac{\Delta d}{\Delta t} \)
\( \Delta d = v\Delta t \)
\( \Delta d = (1498 \text{ m/s})(0.90 \text{ s}) \)
\( \Delta d = 1300 \text{ m} \)

11. \( t_T - t_L = 68 \text{ s} \)
\( \frac{\Delta d}{v_T} - \frac{\Delta d}{v_L} = 68 \text{ s} \)
\( \Delta d \left( \frac{1}{v_T} - \frac{1}{v_L} \right) = 68 \text{ s} \)
\( \Delta d = \frac{68 \text{ s}}{\left( \frac{1}{v_T} - \frac{1}{v_L} \right)} \)
\( \Delta d = \frac{68 \text{ s}}{\left( \frac{1}{5.1 \text{ km/s}} - \frac{1}{8.9 \text{ km/s}} \right)} \)
\( \Delta d = \boxed{810 \text{ km}} \)