Waves

Read from Lesson 1 of the Waves chapter at The Physics Classroom:

http://www.physicsclassroom.com/Class/waves/u10l1a.html
http://www.physicsclassroom.com/Class/waves/u10l1b.html
http://www.physicsclassroom.com/Class/waves/u10l1c.html

MOP Connection: Waves: sublevel 1

TRUE or FALSE: Identify the following statements as being either true (T) or false (F).

T or F?

1. Waves are created by a vibration.

2. As a wave moves through a medium, the individual particles of the medium move from the source of the wave to another location some distance away.

3. Waves are a means of transporting energy from one location to another without actually displacing matter from one location to another.

4. An ocean wave will transport ocean water from near the middle of the ocean to a location near the shore.

5. As mechanical waves move through a medium, particles of the medium undergo a periodic and repeated vibration about a fixed position.

6. Describe how a wave is different than a pulse.

7. Mechanical waves propagate or move through a medium because _______.
   a. the particles of the medium are able to move along the curved wavelike pathway
   b. one particle pushes or pulls on the adjacent particle which pushes or pulls on the next particle which ...
   c. the initial vibration of the medium causes the medium to assume the wavelike shape and this shape subsequently moves from one location to another.

8. Which of the following categories of waves require a medium in order to transport energy from one location to another?
   a. mechanical
   b. electromagnetic
9. **What’s Wrong With This?**

   Suppose you’re watching a science fiction movie and one of the scenes involves a spaceship battle in outer space. Spaceship A launches a successful strike on spaceship B. The scene is presented from the perspective of spaceship A. The occupants of spaceship A view spaceship B blowing up as the result of the successful missile strike. They see the flames of the explosion and shortly thereafter hear the thunderous sound of the explosion.

   While the scene is definitely exciting, there is a significant fault with it in terms of the physics. What law of physics was violated in the filming of the scene? Explain.

10. The arrows on the diagrams below represent the direction of particle motion.

   ![Diagram A](image.png) ![Diagram B](image.png)

   Diagram A shows a ____ pulse and diagram B shows a ____ pulse.
   a. longitudinal, transverse  
   b. transverse, longitudinal

11. Compare the direction in which particles of the medium vibrate for a longitudinal wave compared to a transverse wave. Reference the diagram in question #10 in your discussion.
Describing Waves

Read from Lesson 2 of the Waves chapter at The Physics Classroom:

http://www.physicsclassroom.com/Class/waves/u10l2a.html
http://www.physicsclassroom.com/Class/waves/u10l2b.html
http://www.physicsclassroom.com/Class/waves/u10l2c.html
http://www.physicsclassroom.com/Class/waves/u10l2d.html

MOP Connection: Waves: sublevels 2 and 3

1. A wave is introduced into a medium and a snapshot of the medium at a particular instant in time is shown at the right. Several positions along the medium are labeled. Categorize the positions as either crests or troughs.
   
   Crests: ___________________   Troughs: ___________________   Neither: ___________________

2. The wavelength of the wave in the diagram below is given by letter _____ and the amplitude of the wave in the diagram below is given by letter _____.

3. A sine curve that represents a transverse wave is drawn below. Use the centimeter ruler to measure the wavelength and amplitude of the wave (show units).

   a. Wavelength = __________   b. Amplitude = __________

4. The number of cycles of a periodic wave per unit time is called the wave’s ____________.

5. Any repeated and periodic motion can be described by a frequency. For instance, the frequency of rotation of a second hand on a clock is _______.
   
   a. 1/60 Hz   b. 1/12 Hz   c. 1/2 Hz   d. 1 Hz   e. 60 Hz

6. A pendulum makes 40 vibrations in 20 seconds. Calculate its period?

   Throughout this unit, internalize the meaning of terms such as period, frequency, wavelength and speed. Utilize the meaning of these terms to answer conceptual questions; avoid formula fixation.
Wave Basics

7. Olive Udadi accompanies her father to the park for an afternoon of fun. While there, she hops on the swing and begins a motion characterized by a complete back-and-forth cycle every 5.0 seconds. This statement provides info about the child’s _____.
   a. speed  b. frequency  c. period

8. The frequency of Olive’s periodic motion (in #7) is _____.
   a. 0.20 Hz  b. 0.40 Hz  c. 2.5 Hz  d. 5.0 Hz

9. A period of 5.0 seconds corresponds to a frequency of ____ Hz.
   a. 0.20  b. 0.50  c. 0.020  d. 0.050  e. 0.0020

10. The period of a 261-Hertz sound wave is ______________.

11. As the frequency of a wave increases, the period of the wave _________.
    a. decreases  b. increases  c. remains the same

12. The speed of a wave refers to
    a. how often it vibrates to and fro.
    b. how high it vibrates.
    c. how much time it takes to vibrate to and fro.
    d. how far a given point (e.g., a crest) on the wave travels per unit of time.

13. Write the two equations that can be used to determine the speed of a wave.

14. Mac and Tosh are resting on top of the water near the end of the pool when Mac creates a surface wave. The wave travels the length of the pool and back in 25 seconds. The pool is 25 meters long. Determine the speed of the wave. PSYW

15. A fisherman uses a sonic ranger to determine the depth of a lake. The sound waves travel at 1210 m/s through the water and require 0.020 seconds to travel to the lake’s bottom and back to the boat. How deep is the lake? PSYW

16. The water waves below are traveling with a speed of 3.0 m/s and splashing periodically against the Wilbert’s perch. Each adjacent crest is 6.0 meters apart and splashes Wilbert’s feet upon reaching his perch. How much time passes between each successive drenching? ____________ Answer and explain using complete sentences or a calculation.
Boundary Behavior

Read from Lesson 3 of the Waves chapter at The Physics Classroom:
http://www.physicsclassroom.com/Class/waves/u10l3a.html

MOP Connection: Waves: sublevel 5

Background:
The behavior of a traveling wave (or pulse) upon reaching the end of a medium is referred to as **boundary behavior**. When one medium ends, another medium begins; the interface of the two media is referred to as the **boundary** and the behavior of a wave at that boundary is described as its boundary behavior. A pulse that is approaching a boundary is referred to as the **incident pulse**. Upon reaching the boundary, a portion of the incident pulse will be reflected and remain in the same medium; and a portion of the incident pulse will pass into (or be transmitted into) the other medium which lies beyond the boundary. The portion of the pulse that is reflected is referred to as the **reflected pulse** and the portion that passes into the other medium is referred to as the **transmitted pulse**. A proper understanding of the boundary behavior of waves involves an ability to answer the following questions.

Fixed and Free End Reflection:
1. State the rule that describes how a pulse will behave at a free- and a fixed-end.

2. Express your understanding of reflection of waves at the end of a medium by drawing the size and orientation of the reflected pulse for the two cases below - reflection off a free end and a fixed end.

   **Fixed End Reflection**
   - Incident Pulse
   - Reflected Pulse

   **Free End Reflection**
   - Incident Pulse
   - Reflected Pulse

Reflection and Transmission of an Incident Pulse at a Boundary Between Two Media:
A pulse is moving from a more dense medium to a less dense medium as shown in the diagram below.

3. The reflected pulse in medium 1 ________ (will, will not) be inverted because ______________________

4. The speed of the transmitted pulse will be ___________ (greater than, less than, the same as) the speed of the incident pulse.

5. The speed of the reflected pulse will be ___________ (greater than, less than, the same as) the speed of the incident pulse.

6. The wavelength of the transmitted pulse will be ___________ (greater than, less than, the same as) the wavelength of the incident pulse.
Wave Basics

A pulse is moving from a less dense medium to a more dense medium as shown in the diagram below.

7. The reflected pulse in medium 2 ________ (will, will not) be inverted because ______________

8. The speed of the transmitted pulse will be ___________ (greater than, less than, the same as) the speed of the incident pulse.

9. The speed of the reflected pulse will be ___________ (greater than, less than, the same as) the speed of the incident pulse.

10. The wavelength of the transmitted pulse will be ___________ (greater than, less than, the same as) the wavelength of the incident pulse.

11. Summarize your understanding of boundary behavior by completing the following statements.

   When a wave passes across the boundary from one medium to another medium, the ...
   ... speed is _______________ (greatest, smallest) in the least dense media.
   ... wavelength is _______________ (greatest, smallest) in the least dense media.
   ... the reflected pulse becomes inverted only when the incident wave is in the __________ (more, less)
   dense medium and heading toward the ___________ (more, less) dense medium.

12. Express your understanding of the rules of boundary behavior by drawing the reflected and transmitted pulses in the following two situations. Show the orientation (inverted or non-inverted, wavelength and speed) of each pulse.

   12. Incident pulse is in the more dense medium and traveling toward the less dense medium.

   13. Incident pulse is in the less dense medium and traveling toward the more dense medium.
Boundary Behavior

Read from Lesson 3 of the Waves chapter at The Physics Classroom:
http://www.physicsclassroom.com/Class/waves/u10l3a.html

MOP Connection: Waves: sublevel 5

Background:
The behavior of a traveling wave (or pulse) upon reaching the end of a medium is referred to as boundary behavior. When one medium ends, another medium begins; the interface of the two media is referred to as the boundary and the behavior of a wave at that boundary is described as its boundary behavior. A pulse that is approaching a boundary is referred to as the incident pulse. Upon reaching the boundary, a portion of the incident pulse will be reflected and remain in the same medium; and a portion of the incident pulse will pass into (or be transmitted into) the other medium which lies beyond the boundary. The portion of the pulse that is reflected is referred to as the reflected pulse and the portion that passes into the other medium is referred to as the transmitted pulse. A proper understanding of the boundary behavior of waves involves an ability to answer the following questions.

Fixed and Free End Reflection:
1. State the rule that describes how a pulse will behave at a free- and a fixed-end.

2. Express your understanding of reflection of waves at the end of a medium by drawing the size and orientation of the reflected pulse for the two cases below - reflection off a free end and a fixed end.

Reflection and Transmission of an Incident Pulse at a Boundary Between Two Media:
A pulse is moving from a more dense medium to a less dense medium as shown in the diagram below.

3. The reflected pulse in medium 1 ________ (will, will not) be inverted because ______________________

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A pulse is moving from a less dense medium to a more dense medium as shown in the diagram below.

7. The reflected pulse in medium 2 ________ (will, will not) be inverted because ____________________________

8. The speed of the transmitted pulse will be ___________ (greater than, less than, the same as) the speed of the incident pulse.

9. The speed of the reflected pulse will be ___________ (greater than, less than, the same as) the speed of the incident pulse.

10. The wavelength of the transmitted pulse will be ___________ (greater than, less than, the same as) the wavelength of the incident pulse.

11. Summarize your understanding of boundary behavior by completing the following statements.

    When a wave passes across the boundary from one medium to another medium, the ...
    ... speed is _______________ (greatest, smallest) in the least dense media.
    ... wavelength is _______________ (greatest, smallest) in the least dense media.
    ... the reflected pulse becomes inverted only when the incident wave is in the __________ (more, less)
    dense medium and heading toward the __________ (more, less) dense medium.

Express your understanding of the rules of boundary behavior by drawing the reflected and transmitted pulses in the following two situations. Show the orientation (inverted or non-inverted, wavelength and speed) of each pulse.

12. Incident pulse is in the more dense medium and traveling toward the less dense medium.

13. Incident pulse is in the less dense medium and traveling toward the more dense medium.
Interference of Waves

Read from Lesson 3 of the Waves chapter at The Physics Classroom:
http://www.physicsclassroom.com/Class/waves/u10l3c.html

MOP Connection: Waves: sublevel 6

TRUE or FALSE: Identify the following statements as being either true (T) or false (F).

1. When two pulses meet up with each other while moving through the same medium, they have a tendency to bounce off each other and return back to their origin.  
   T or F?

2. Constructive interference occurs when a crest meets up with another crest at a given location along the medium.
   T or F?

3. Destructive interference occurs when a pulse with an amplitude of +5 units interferes with a pulse with an amplitude of -5 units.
   T or F?

4. Destructive interference occurs when a trough meets up with another trough at a given location along the medium.
   T or F?

5. If a pulse with an amplitude of +5 units interferes with a pulse with an amplitude of +3 units, the resulting amplitude of the medium will be +4 units - the average of the two individual amplitudes.
   T or F?

6. If a pulse with an amplitude of +5 units interferes with a pulse with an amplitude of -3 units, then neither constructive nor destructive interference occurs.
   T or F?

7. Two sound waves could never interfere in such a manner as to cancel each other out and produce silence.
   T or F?

Principle of Superposition: The effect of two interfering waves upon a medium is to produce a resulting shape and size that is the combination of the shapes and sizes of the individual waves. The amount of displacement of the medium at any given location is simply the vector sum of the displacement of the two individual waves at that location.

8. The diagrams below depict two pulses traveling towards each other and at the moment when they are completely superimposed on each other. For each diagram, sketch the resultant of the two pulses during the interference. Finally, indicate if the example represents a case of constructive or destructive interference.

<table>
<thead>
<tr>
<th>&quot;Snapshot&quot; of Two Pulses Before and During Interference</th>
<th>Constructive or Destructive?</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEFORE INTERFERENCE</td>
<td>DURING INTERFERENCE</td>
</tr>
<tr>
<td>BEFORE INTERFERENCE</td>
<td>DURING INTERFERENCE</td>
</tr>
</tbody>
</table>
9. Two waves are traveling along the same medium. The diagrams below show the waves on the medium at an instant in time. Utilize the principle of superposition in order to construct the shape of the medium at the instant shown in each diagram. To do so, begin by determining the resulting displacement of the medium at each of the marked locations (†). Approximate the shape of the remainder of the medium by sketching from dot to dot.

10. Several of the marked positions (†) above are labeled with a letter. Categorize each labeled position along the medium as being a position where either constructive or destructive interference occurs.

<table>
<thead>
<tr>
<th>Constructive Interference</th>
<th>Destructive Interference</th>
</tr>
</thead>
<tbody>
<tr>
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