Boundary Behavior of Waves

Background:

Waves are energy transport phenomenon that carry energy through a medium from one end to another. When a wave reaches the end of a medium, its energy must go somewhere? Does it bounce back and stay in the medium? Does it pass across to whatever is attached to the medium? Does it altogether vanish? Are there any patterns to the behavior that could be expressed in the form of principles or *rules*?

Getting Ready:

Navigate to the **Boundary Behavior of Waves** at TPC (www.physicsclassroom.com).
Home ==> Physics Interactives ==> Waves and Sound ==> Boundary Behavior of Waves

Tap **Launch Interactive**. Resize the Interactive as desired using the re-sizing tab in the bottom right. Tap on the Start button to begin your four-part investigation.

Investigation 1: Density and Speed

How does the density of a medium affect the speed at which a pulse moves through the medium? Make sure **Density and Speed** is highlighted at the top of the simulation. Then run several simulations with varying density values. Observe how fast (i.e., the speed) the pulse travels from one end of the medium to the other.

1. Make a statement describing the effect of a medium's density upon the speed.

Investigation 2: Fixed End Reflection

Tap on **Reflection: Fixed End** at the top of the simulation to select it. A fixed end is an end of a medium in which the last particle is not free to move up and down. A rope secured to a pole at one of its ends would be an example of a fixed end. When a pulse reaches that end, it is unable to vibrate.

2. Run the simulation and observe the behavior at the fixed end. Use some detail to describe what happens.

3. Is there a noticeable change in the speed or the wavelength of the **reflected pulse** compared to the **incident pulse**?

Investigation 3: Free End Reflection

Tap on **Reflection: Free End** at the top of the simulation to select it. A free end is an end of a medium in which the last particle is free to move up and down. A rope that is loosely looped around a pole at one of its ends would be an example of a free end. When a pulse reaches that end, the end is capable of moving up and down.

4. Run the simulation and observe the behavior at the free end. Describe how it is different than a fixed end reflection.

Investigation 4: Boundary Crossing

Tap on **Boundary Crossing** at the top of the simulation to select it. Now we will observe an **incident pulse** reaching a boundary. A portion of the energy will return as a **reflected pulse** and a portion will pass into the new medium as a **transmitted pulse**. You will compare wavelength, speed, amplitude, and orientation (crest or trough) of the incident, reflected, and transmitted pulses.

Crossing a Boundary From a Less Dense to a More Dense Medium

Repeat several trials for a pulse moving from a less dense medium towards a boundary with a more dense medium. Make observations and answer the following questions:

5. The **reflected** pulse will: a. be inverted. b. not be inverted.

6. The speed of the **transmitted** pulse will be _____ the speed of the **incident** pulse.
   a. greater than b. less than c. the same as

7. The speed of the **reflected** pulse will be _____ the speed of the **incident** pulse.
   a. greater than b. less than c. the same as

8. The wavelength of the **transmitted** pulse will be _____ the wavelength of the **incident** pulse.
   a. greater than b. less than c. the same as

9. The wavelength of the **reflected** pulse will be _____ the wavelength of the **incident** pulse.
   a. greater than b. less than c. the same as

10. The amplitude of the **reflected** pulse will be _____ the amplitude of the **incident** pulse.
    a. greater than b. less than c. the same as

11. As the relative density of the two media become more similar (or even identical), the amount of energy that crosses the boundary will _______ and the amount of energy that reflects will _________.
    a. increase, increase b. increase, decrease
    c. decrease, decrease d. decrease, increase

Crossing a Boundary From a More Dense to a Less Dense Medium

12. The **reflected** pulse will: a. be inverted. b. not be inverted.

13. The speed of the **transmitted** pulse will be _____ the speed of the **incident** pulse.
    a. greater than b. less than c. the same as

14. The speed of the **reflected** pulse will be _____ the speed of the **incident** pulse.
    a. greater than b. less than c. the same as

15. The wavelength of the **transmitted** pulse will be _____ the wavelength of the **incident** pulse.
    a. greater than b. less than c. the same as

16. The wavelength of the **reflected** pulse will be _____ the wavelength of the **incident** pulse.
    a. greater than b. less than c. the same as

17. The amplitude of the **reflected** pulse will be _____ the amplitude of the **incident** pulse.
    a. greater than b. less than c. the same as

Conclusions:

Summarize your understanding by completing the following statements:

For any situation in which a pulse in one medium approaches the boundary with a second medium having a different density, 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 pulse is in the __________ (more, less) dense medium and heading toward the __________ (more, less) dense medium.