Waves: Boundary Behaviour Lesson (worksheet) – Answer key

Physics 11 - Boundary Behaviour

Use the following devises to demonstrate the following situations of reflection and transmission of waves at a boundary.

- snaky (long slinky) – available in the classroom
- interactive simulation: https://phet.colorado.edu/en/simulation/wave-on-a-string
- simulation: http://www.acs.psu.edu/drussell/Demos/reflect/reflect.html

1. ***Low density to high density boundary:*** Create a wave in a lower density medium, directed toward a higher density medium e.g. one person holds the end of a snaky firmly, mimicking a wall (high density/fixed end), while their partner creates a pulse in the low density/loose end of the snaky. Describe the ***reflected pulse*** in comparison to the incident pulse:
    i. Upright or inverted? _____inverted_____
    ii. Amplitude – smaller/equal/greater? equal (if the boundary is rigid and there is no transmitted pulse)
    iii. Speed – smaller/equal/greater? equal (it reflects back into the same medium, therefore same speed)

2. ***High density to low density boundary:*** Create a wave in a high density medium, directed toward a low density medium e.g. one end of the snaky is loosely connected to a metal bar so that it can slide easily (low density), while a pulse is created at the other end (high density). Describe the ***reflected pulse*** in comparison to the incident pulse:
    i. Upright or inverted? _____upright_____
    ii. Amplitude – smaller/equal/greater? equal (if the boundary is very loose and there is no transmitted pulse)
    iii. Speed – smaller/equal/greater? equal (it reflects back into the same medium, therefore same speed)

3. Use the interactive simulation (https://phet.colorado.edu/en/simulation/wave-on-a-string) to demonstrate the situations described in questions 1 and 2. At the bottom, set "damping" to "none", and "tension" to "high".
    i. Try the different settings on the top left – *manual, oscillate, and pulse*. For our purposes, which setting best helps us demonstrate the concept of wave behaviour at a boundary? __manual or pulse_____
    ii. Try the different settings on the top right – *fixed end, loose end, and no end*. Does the simulation match the results when using a snaky in the classroom?
    _____

iii. Adjust the "damping" setting to a higher value. What effect does increased damping have on the wave? (then, return "damping" to "none" before moving on to the next step). ____amplitude decreases more quickly (damping is like friction – wave energy is transferred to other forms of energy such as heat or sound, thus reducing the amplitude)_____

iv. Adjust the "tension" setting to a lower value. What effect does decreased tension have on the wave? ____decreased tension reduces wave speed

4. Refer to this simulation to observe waves at a boundary where both reflection and transmission take place (scroll down the page to see the relevant simulation): http://www.acs.psu.edu/drussell/Demos/reflect/reflect.html

   a. ***High speed (low density) to low speed (high density) medium:***

      i. Describe the ***transmitted pulse*** in comparison to the incident pulse:

         1. Upright or inverted? _____upright_____
         2. Amplitude – smaller/equal/greater? _____smaller_____
         3. Speed – smaller/equal/greater? _____smaller_____
         4. Width of the pulse (wavelength) _smaller ($\lambda = v/f$). Since speed decreases, and frequency remains the same, wavelength must be smaller
         5. Frequency of the pulse equal (frequency depends on the source of the wave, not the properties of the medium)_____

      ii. Describe the ***reflected pulse*** in comparison to the incident pulse:

         1. Upright or inverted? _____inverted_____
         2. Amplitude – smaller/equal/greater? smaller (some energy was transmitted)
         3. Speed – smaller/equal/greater? __equal (same medium)_
         4. Width of the pulse (wavelength) equal (same medium, same speed, same f, therefore same $\lambda = v/f$)_ _
         5. Frequency of the pulse equal (frequency depends on the source of the wave, not the properties of the medium)_____

   b. ***Low speed (high density) to high speed (low density) medium:***

      i. Describe the ***transmitted pulse*** in comparison to the incident pulse:

         1. Upright or inverted? _____upright_____
         2. Amplitude – smaller/equal/greater? _____greater_____
         3. Speed – smaller/equal/greater? _____greater_____

      ii. Describe the ***reflected pulse*** in comparison to the incident pulse:

         1. Upright or inverted? _____upright_____

2. Amplitude – smaller/equal/greater? smaller (some energy was transmitted)
3. Speed – smaller/equal/greater? _____equal (same medium)__

c. What factor determines the relative amplitudes of the transmitted and reflected pulses?
   - Amplitude is related to the energy of the wave. If the properties of the 2 mediums are very similar to each other, most of the energy will be transmitted, thus the transmitted wave will have a larger amplitude.
   - If the properties of the 2 mediums are very different, most of the energy will be reflected and the reflected wave will have a larger amplitude

d. What factor determines the frequency of the incident, reflected, and transmitted pulse (wave)
   - Frequency is determined by the source of the wave, not the medium through which the wave travels. So, incident, reflected, and transmitted waves all have the same frequency.
   - E.g. the source of the wave could be a person's hand shaking a slinky, or an atom emitting electromagnetic waves