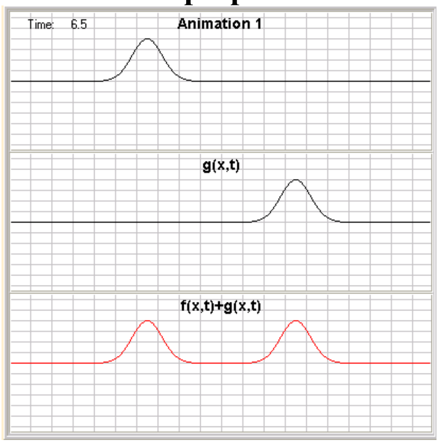
Worksheet: Pulses and Superposition

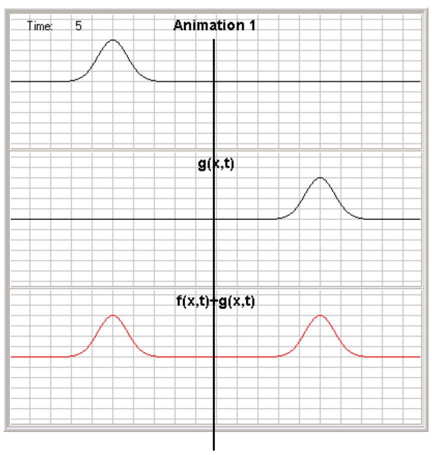
Part I: A. Superposition of Pulses



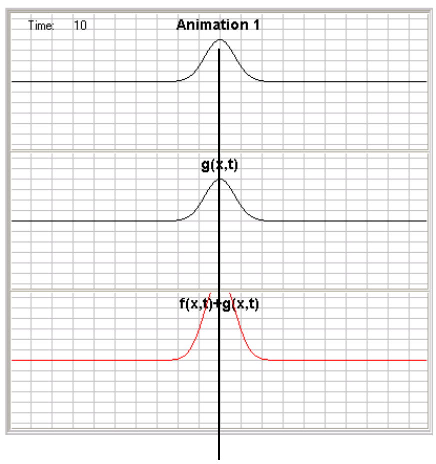
One of the most interesting phenomena we can explore is that of a superposition of waves. A superposition of two waves is nothing more than the arithmetic sum of the amplitudes of the two underlying waves. We can represent the amplitude of a transverse wave by a wave function, y(x, t). Notice that the amplitude, the value y, is a function of position on the x axis and the time. If we have two waves moving in the same medium, we call them y_1(x, t) and y_2(x, t), or in the case of this animation, f(x, t) and g(x, t). Their superposition, arithmetic sum, is written as f(x, t) + g(x, t).

This may seem like a complicated process, so we often focus on the amplitude at one point on the x axis, say x = 0 m **(position is given in meters and time is given in seconds)**. So now let's consider Animation 1, which represents waves traveling on a string. The top panel represents the right-moving Gaussian pulse f(x, t), the middle panel represents g(x, t), the left-moving Gaussian pulse, and the bottom panel represents what you would actually see: the superposition of f(x, t) and g(x, t). Below are a series of snapshots of the waves as the time changes:

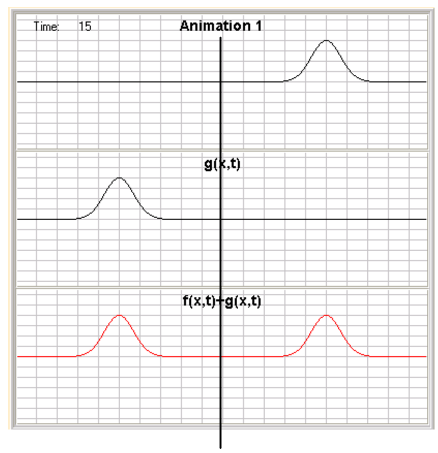
Time elapsed: 5-seconds



10-seconds



15-seconds

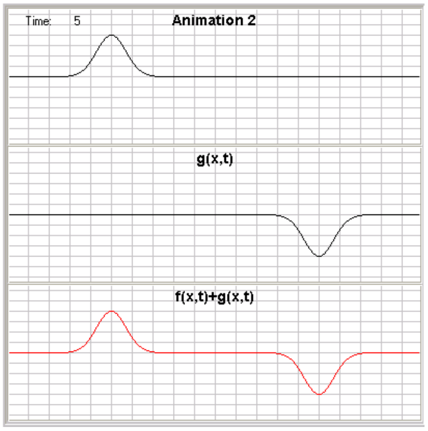


1. Focus on x = 0 m (marked by the vertical line). Until the tail of each wave arrives at x = 0 m, the amplitude there is zero. What happens during the time that the two waves overlap? Explain.

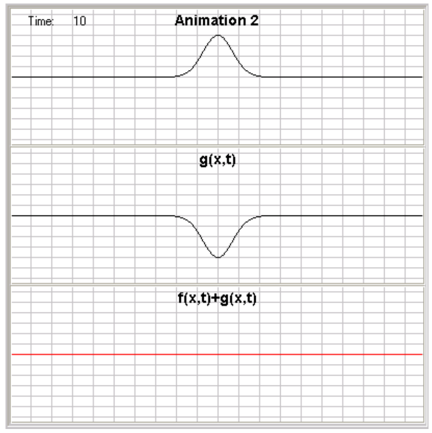
2. What about after the overlap? Explain.

Below shows a second series of traveling pulses.

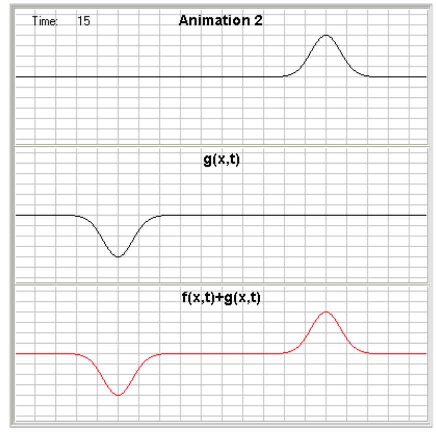
Time elapsed: 5-seconds



Time: 10-seconds



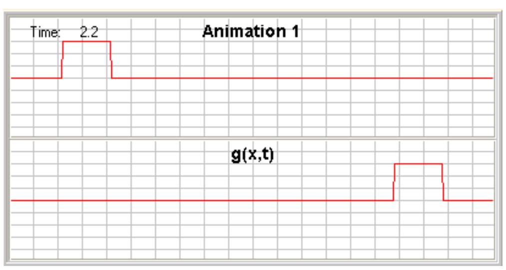
Time: 15-seconds



3. Focus on x = 0 m. What happens during the time that the two waves overlap? Explain.

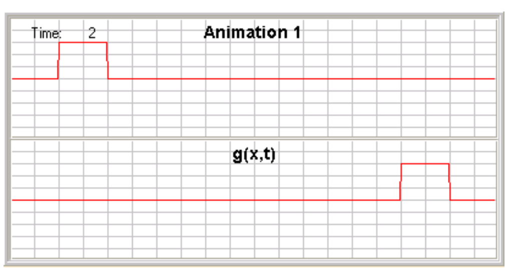
4. What about after the overlap? Explain.

Part II: B. More Superposition of Two Pulses

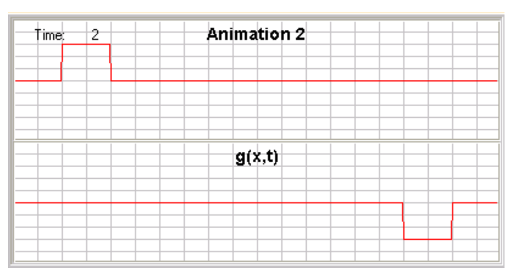


Each plot shows an individual wave that is traveling on a string. If these two waves are traveling on the same string, draw the superposition of the two pulses between t = 0 and t = 20 s in 2-s intervals for each animation if the waves are traveling 1m/s **(each block represents one meter and time is given in seconds)**.

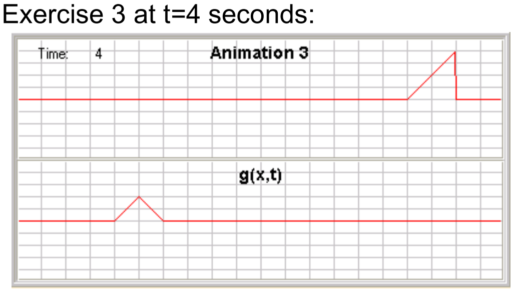
Exercise 1 at time=2 seconds:



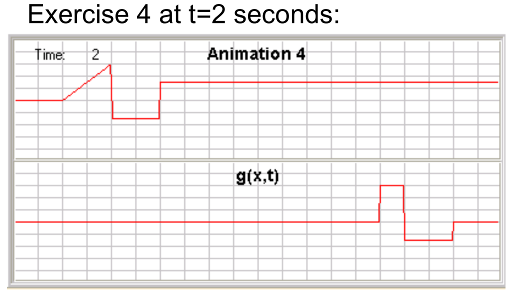
Exercise 2 at time= 2 seconds:



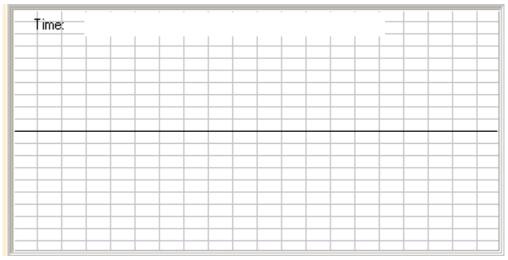
Exercise 3 at t=4 seconds:

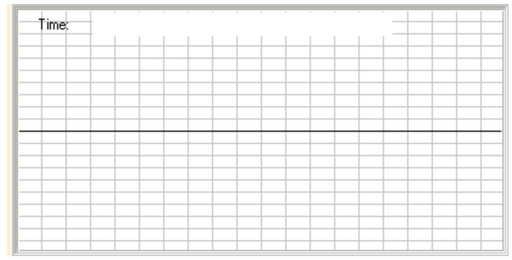


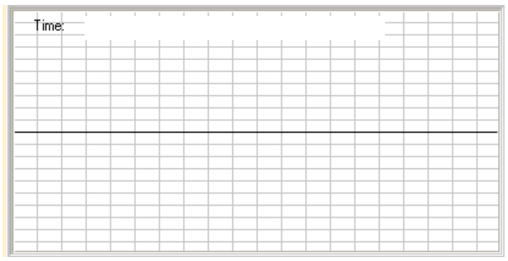
Exercise 4 at t=2 seconds:

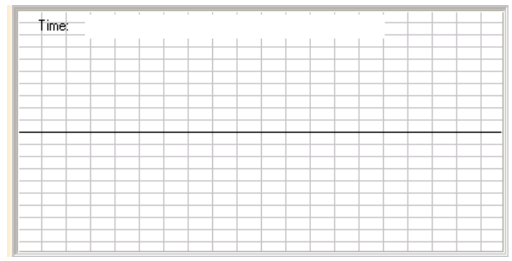


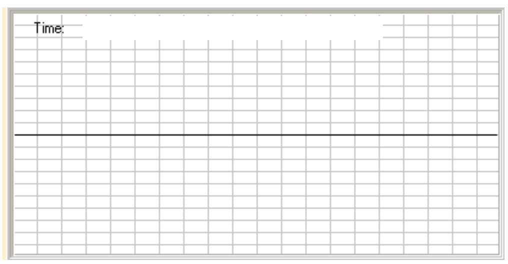
Superposition for Exercise 1:

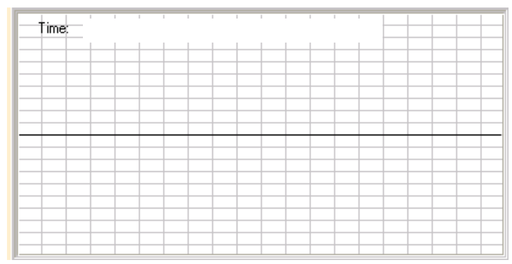


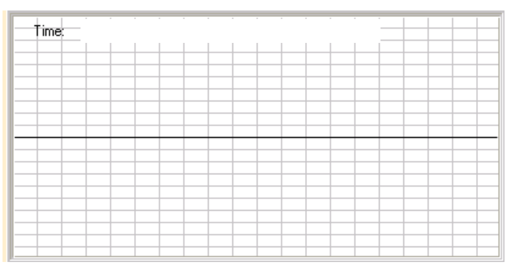


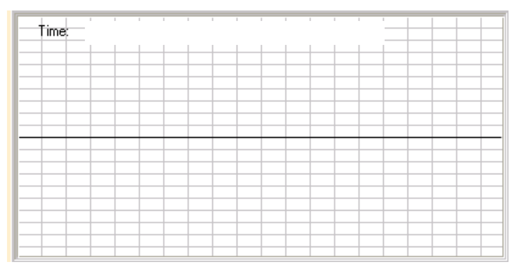


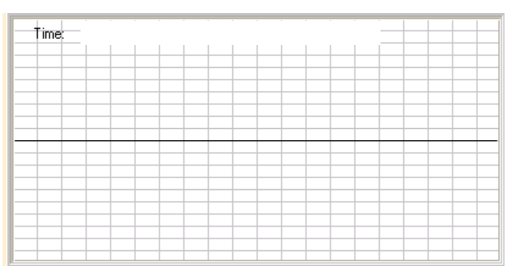


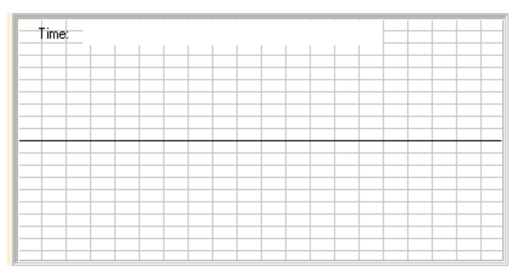




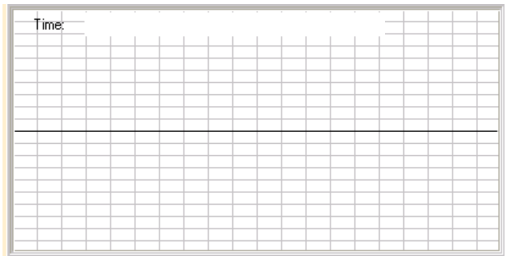


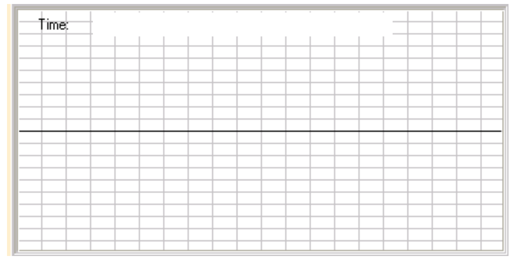


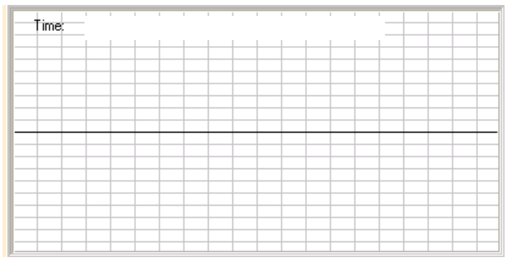


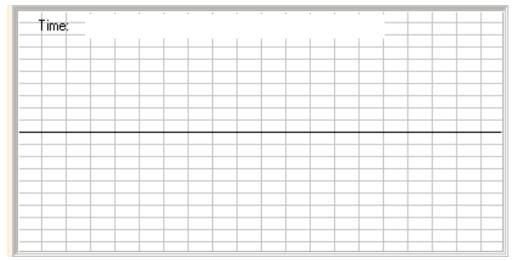


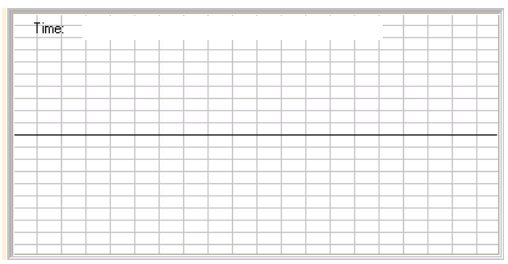
Superposition for Exercise 2:

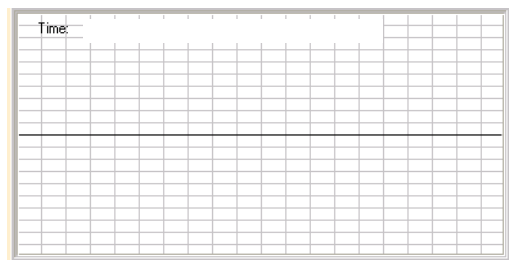


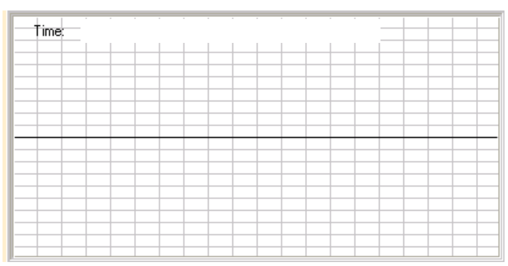


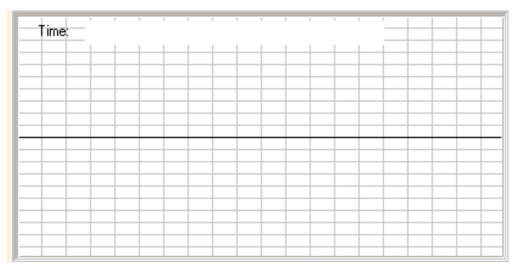


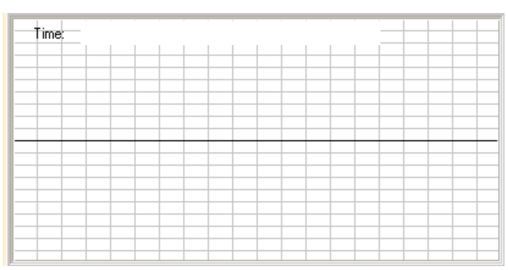


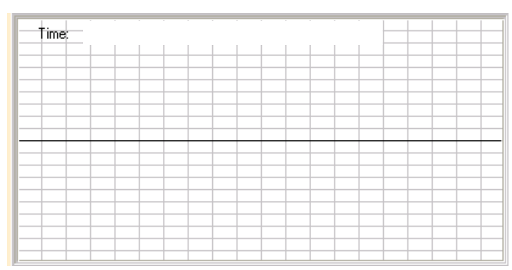




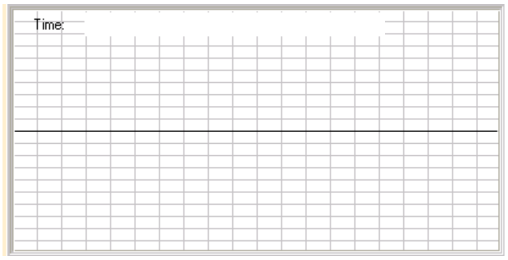


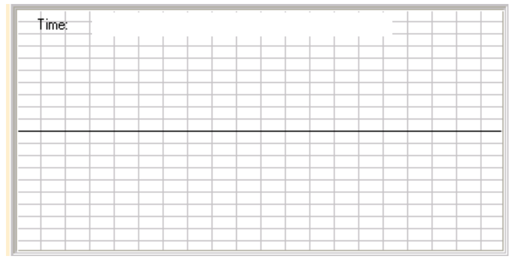


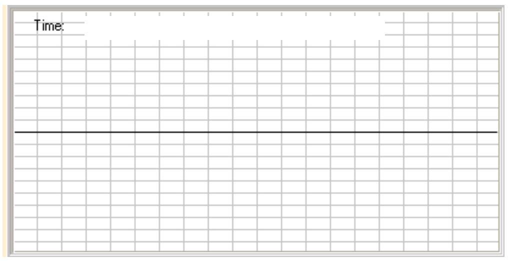


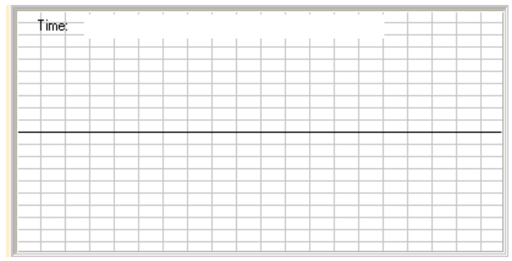


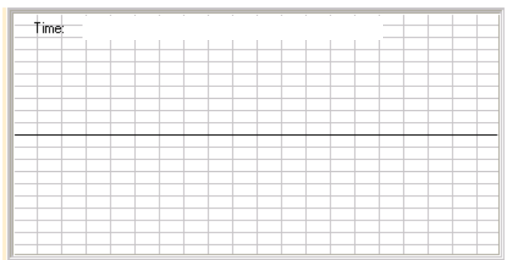
Superposition for Exercise 3:

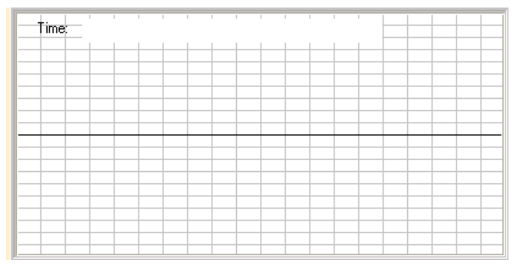


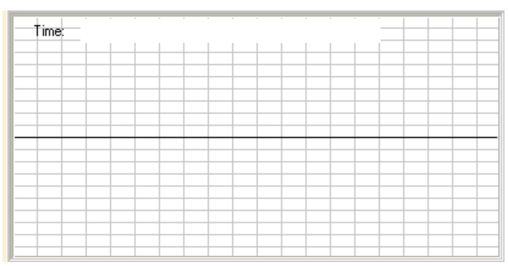


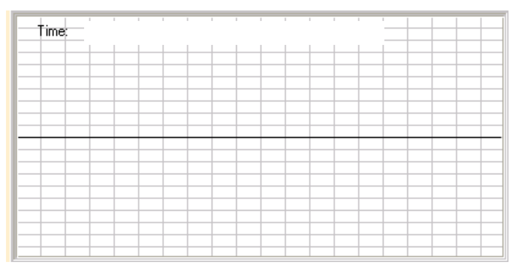


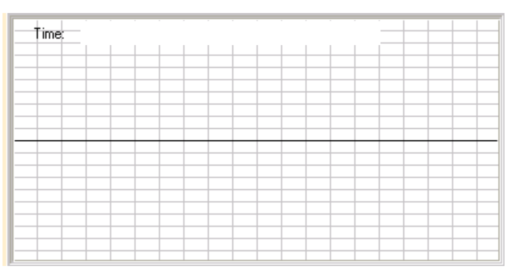


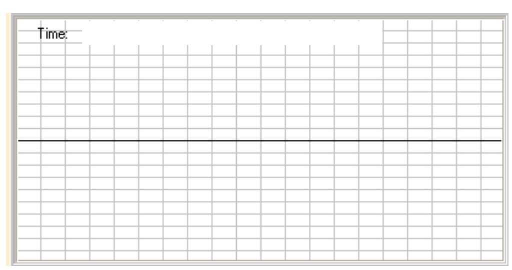








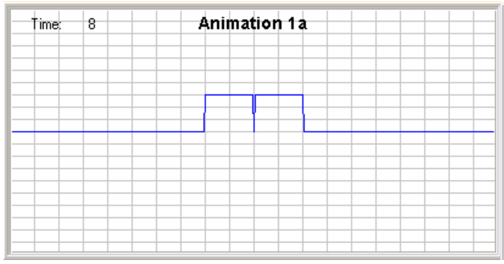


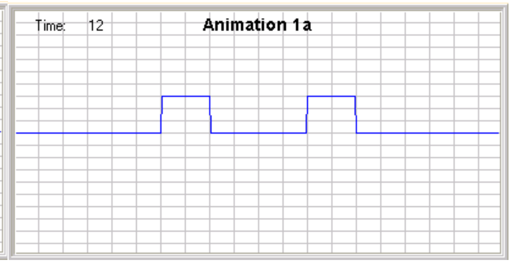


Superposition for Exercise 4:

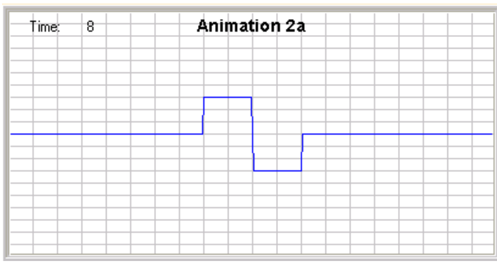
Check some of your answers using the following snapshots of the superposition in at particular times (next page). Are there any differences in your answers? Explain.

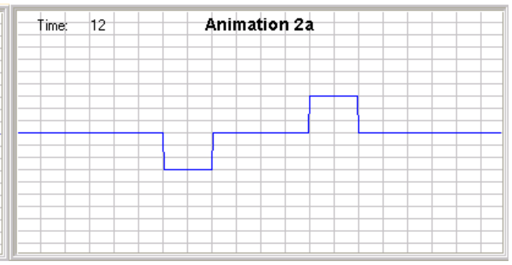
Exercise 1 (selected answers):



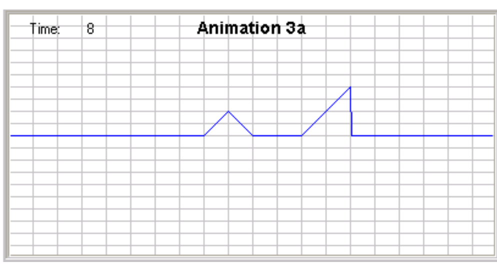


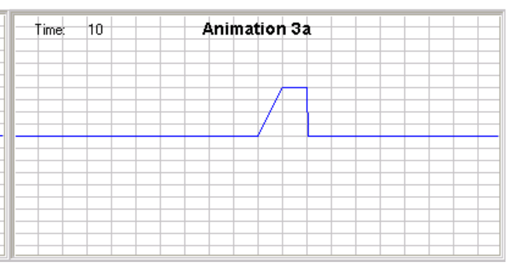
Exercise 2 (selected answers):



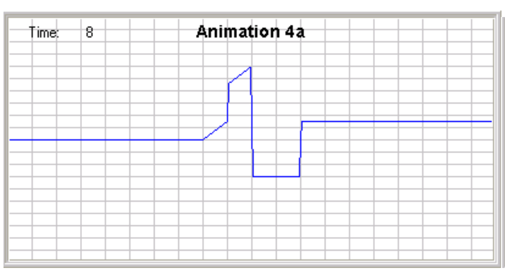


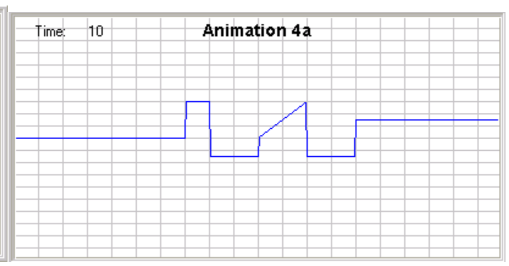
Exercise 3 (selected answers):



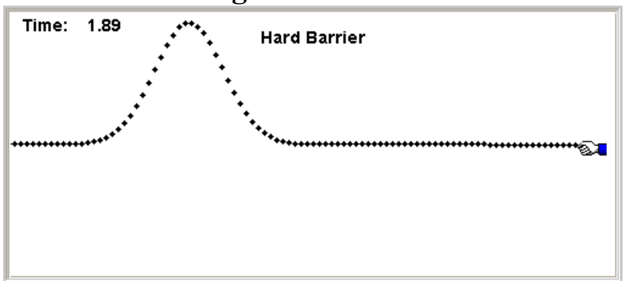


Exercise 4 (selected answers):



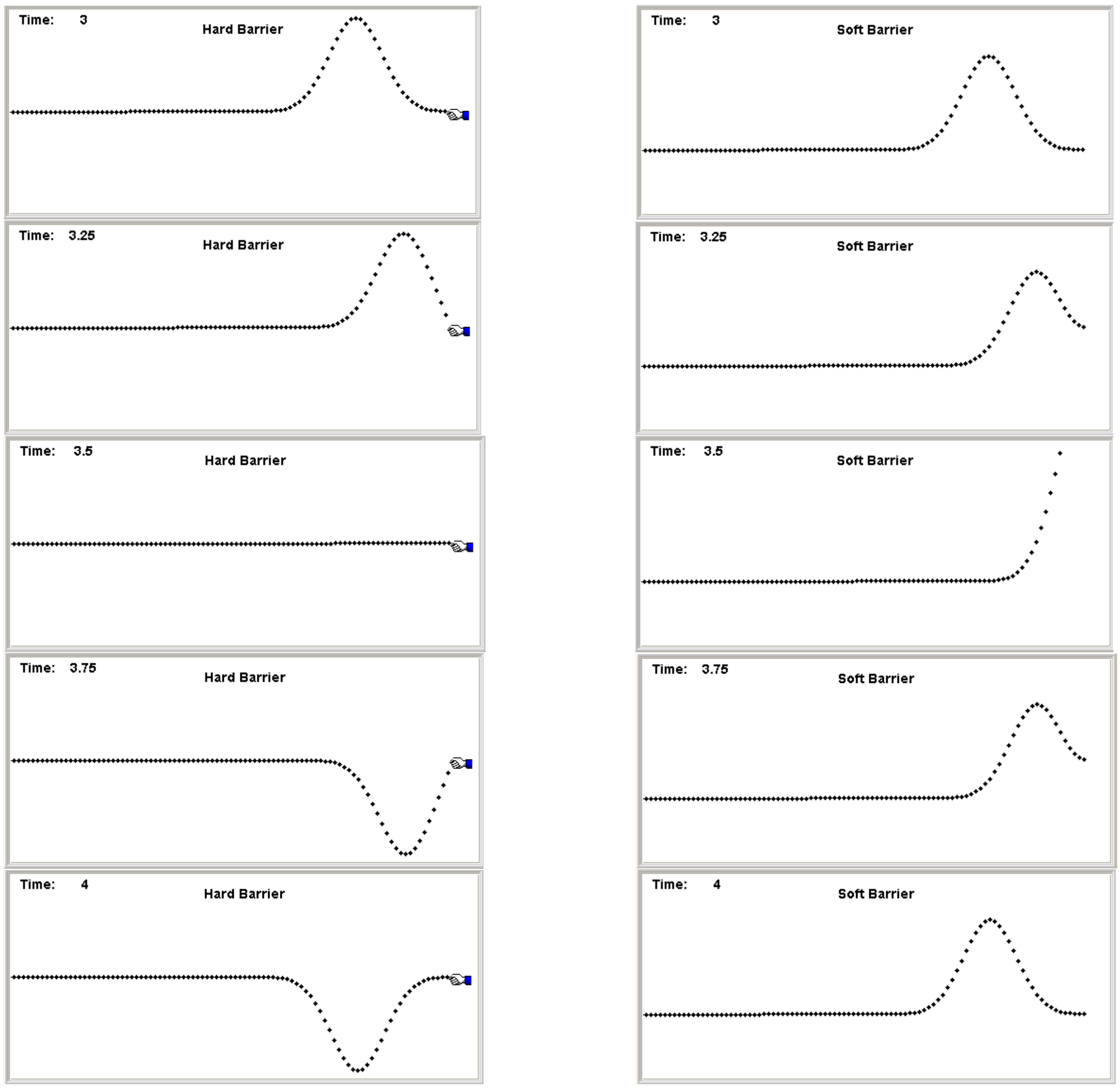


Part II: Traveling Pulses and Barriers



A string can be approximated by many connected particles as shown in the diagram. Here we consider a pulse on a string and looks at the motion of the individual particles that make up such a string. The figure shows a Gaussian pulse incident from the left. The particles never really move in the x direction, yet the information in the pulse does travel along the string. When a pulse hits a barrier and reflects, the reflected wave depends on whether the waves is reflected at a hard barrier (fixed point) or soft barrier (string is allowed to move):

Hard Barrier (Fixed Hand) **Soft Barrier (Open end of string)**



1. Describe the differences between the waves reflected at the two barriers (Hard or Soft).

2. Explain those differences.

One way to think about a pulse hitting a barrier is to consider the pulse that you see as a superposition of two pulses: the one traveling into the barrier and the one coming from just past the barrier (either a mirror reflect or an inverted mirror reflect depending on the barrier) so that the two of them meet when the pulse gets to the barrier.

3. Sketch what the two pulses would look like so that the superposition of the two pulses would give you what you see in the hard barrier case.

4. Sketch the same thing for the soft barrier case.