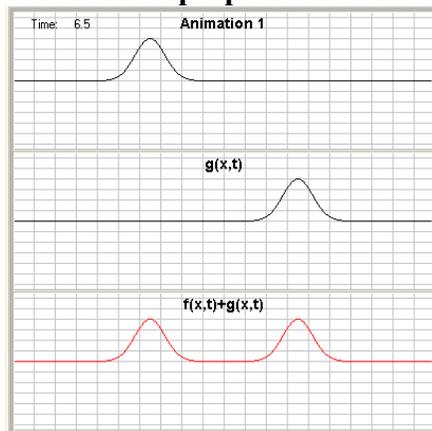


Worksheet: Pulses and Superposition

Part I: A. Superposition of Pulses (from Illustration 17.3, *Physlet Physics*)



One of the most interesting phenomena we can explore is that of a superposition of waves. Restart.

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 $f(x, t) + g(x, t)$.

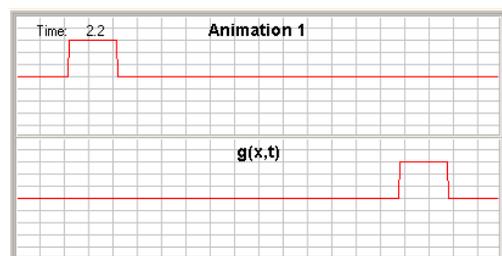
This may seem like a complicated process, so we often focus on the amplitude at one point on the x axis, say $x = 0$ m (**position is given in meters and time is given in seconds**). So now let's consider Animation 1, which represents waves traveling on a string. The top panel represents the right-moving 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 $g(x, t)$.

1. As you play the animation focus on $x = 0$ m. 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 does the superposition in Animation 2 look like at $t = 10$ s?

3. What about at a later time?

Part I: B. Superposition of Two Pulses (from Exploration 17.1, *Physlet Physics*)

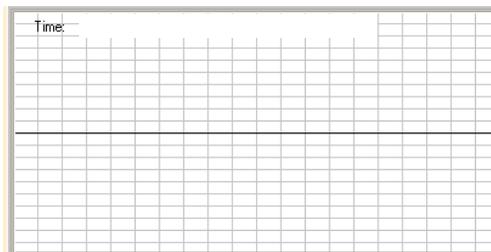
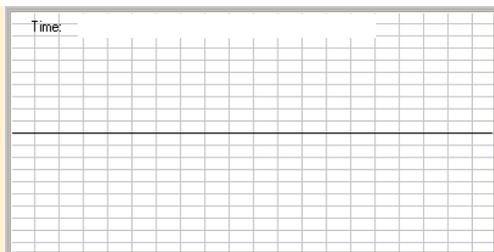
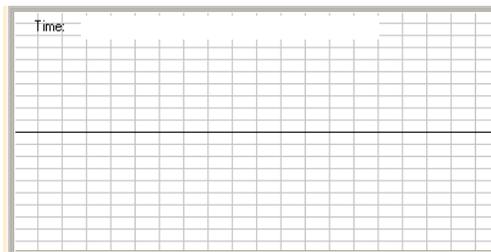
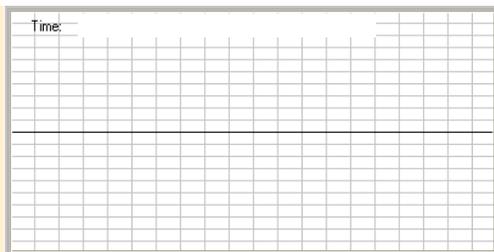
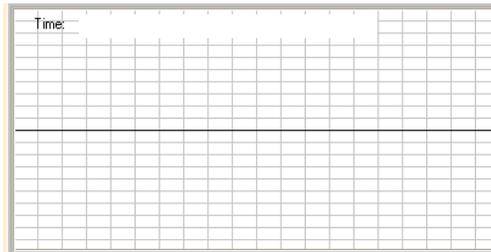
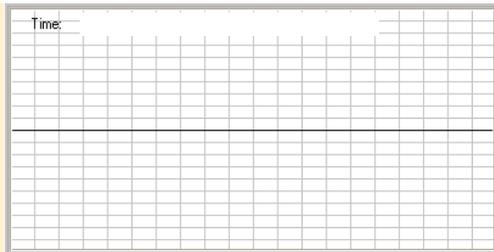
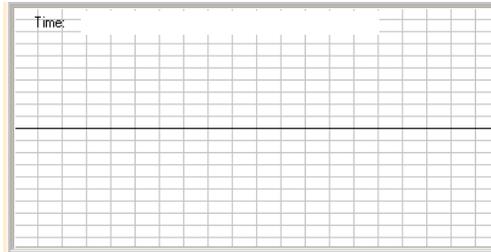
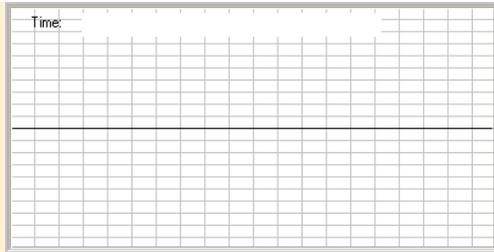
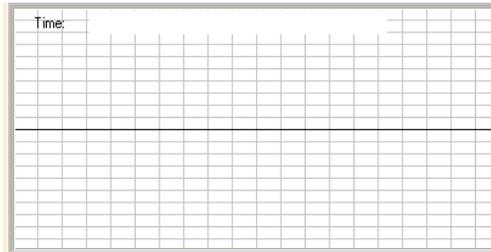
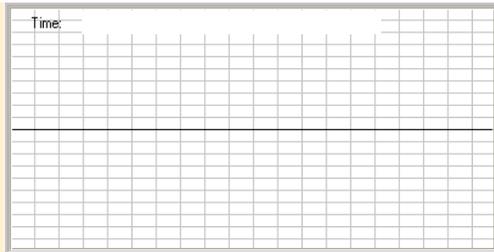


Each panel of this exercise shows an individual wave that is traveling on a string. Restart.

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 (**position is given in meters and time is given in seconds**).

Sketch on the next pages:

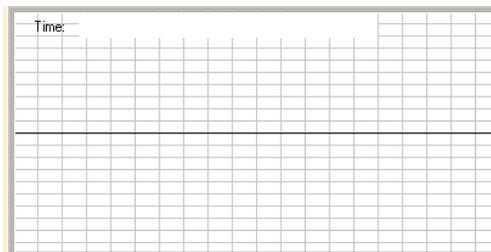
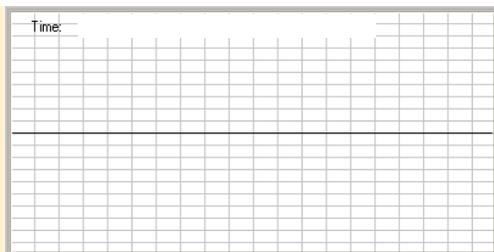
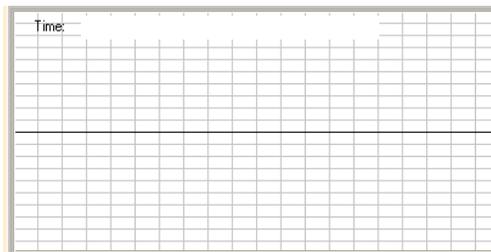
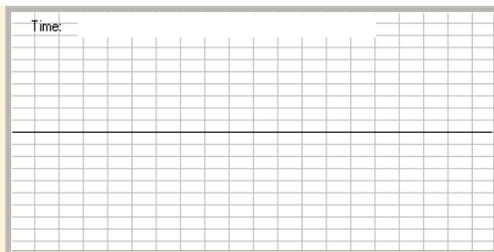
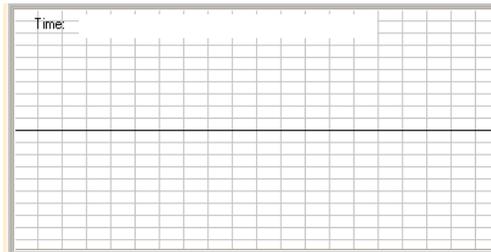
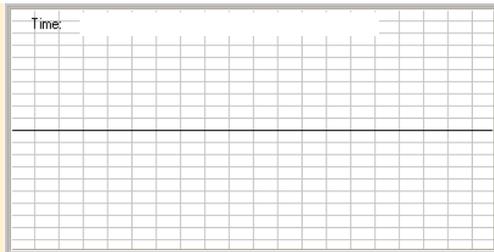
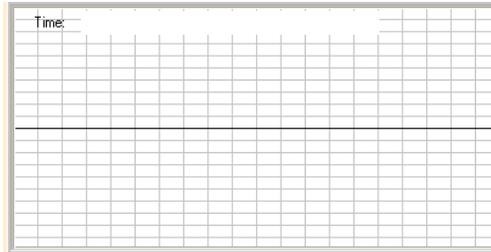
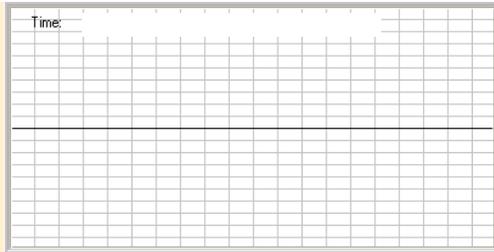
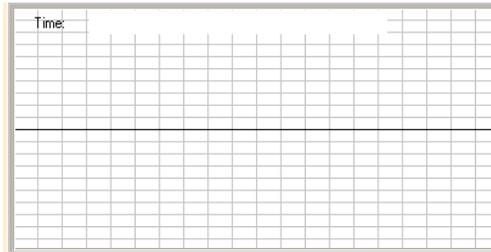
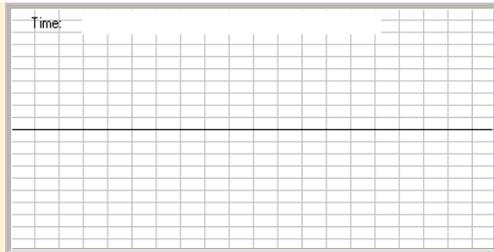
Superposition for Animation 1:



Check your answers against the animation (Animation 1a at the bottom of the page). Are there any differences? Explain.

How fast is each wave traveling?

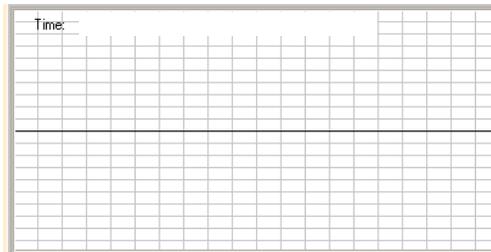
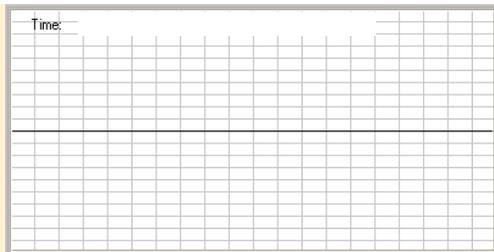
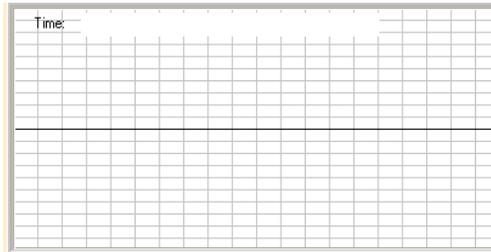
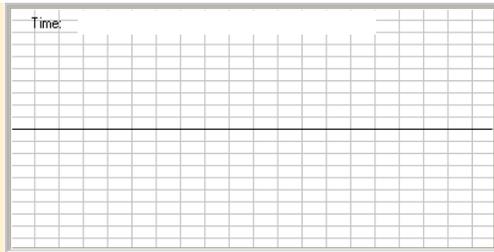
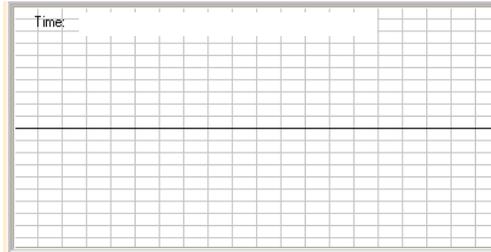
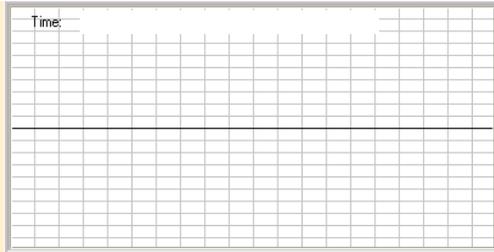
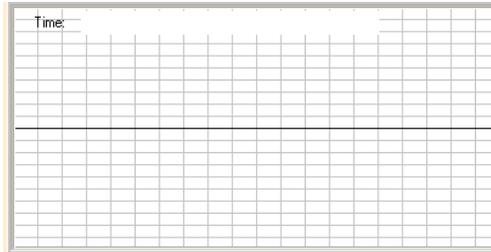
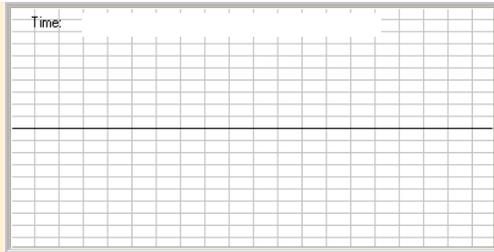
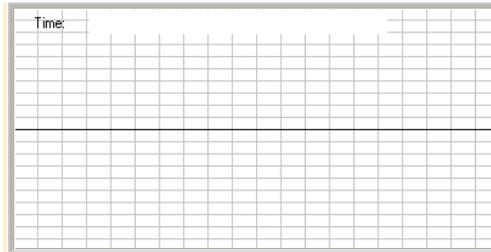
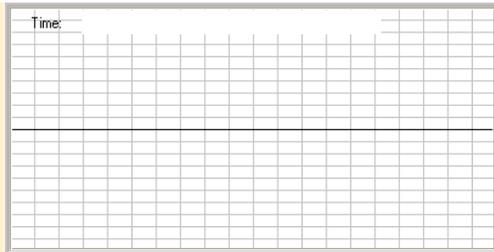
Superposition for Animation 2:



Check your answers against the animation (Animation 2a at the bottom of the page). Are there any differences? Explain.

How fast is each wave traveling?

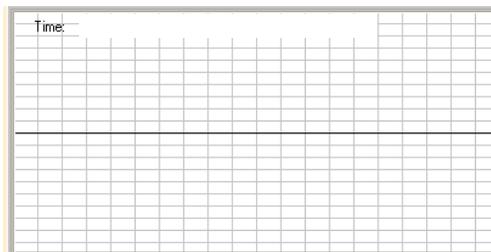
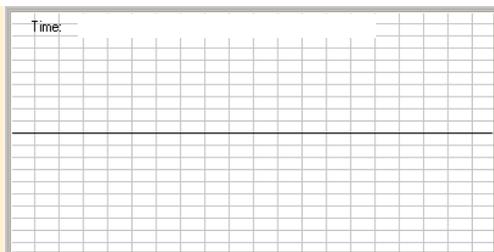
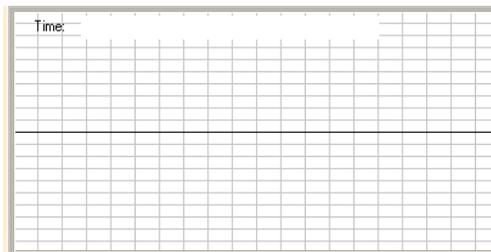
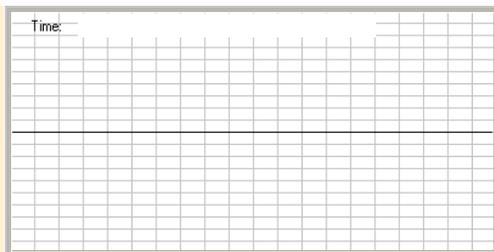
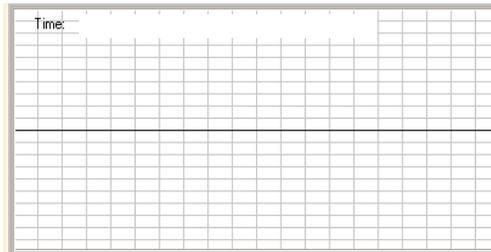
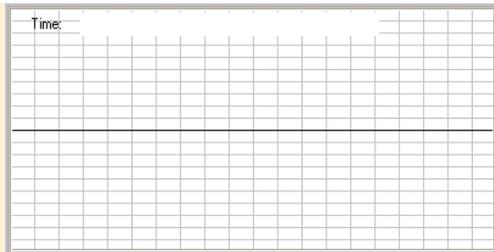
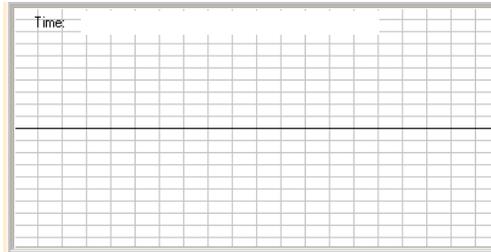
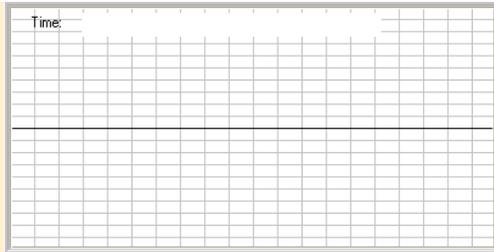
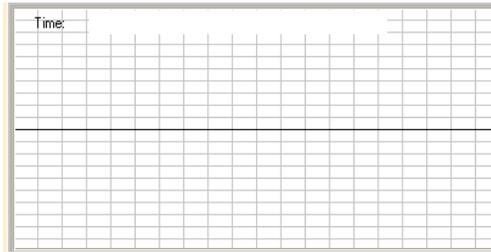
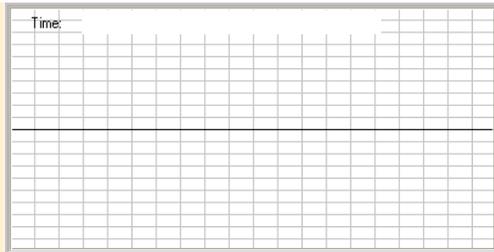
Superposition for Animation 3:



Check your answers against the animation (Animation 3a at the bottom of the page). Are there any differences? Explain.

How fast is each wave traveling?

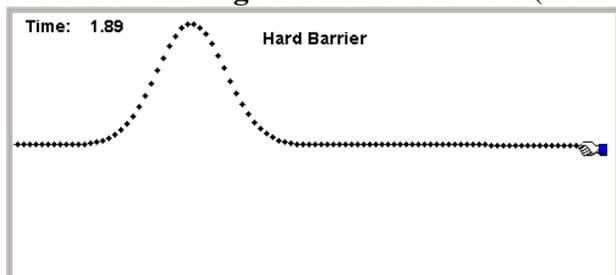
Superposition for Animation 4:



Check your answers against the animation (Animation 4a at the bottom of the page). Are there any differences? Explain.

How fast is each wave traveling?

Part II: Traveling Pulses and Barriers (from Exploration 17.3, *Physlet Physics*)



A string can be approximated by many connected particles as shown in the animations (**position is given in meters and time is given in seconds**). Restart. Here we consider a pulse on a string and looks at the motion of the individual particles that make up such a string.

Look at Pulse 1 (push "play") which shows a Gaussian pulse incident from the left. Now,

look at Pulse 2 which shows a Gaussian pulse incident from the right.

1. Do the individual particles travel in the horizontal direction? What about the pulse itself?

In the other two animations the pulse is incident from the left and hits either a Hard or a Soft barrier. The hard barrier example is depicted by the hand that represents a string whose end is tied down; the soft barrier example represents a string with one end free.

2. Describe the differences between the waves reflected at the two barriers (Hard or Soft).
3. 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.

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