Make-up Lab: Special Relativity

Introduction
Einstein’s re-evaluation of the way the world works provided a theory more complete in its explanations of natural phenomena than Newton’s Laws. Entirely consistent with classical dynamics at low energies, special relativity often presents challenging paradoxes and curious results that are especially difficult for us to wrap our minds around, since we live in a world where the effects are rarely noticeable. This Physlets lab will allow you a chance to explore some of the basic concepts of Special Relativity in a simulated, controlled environment.

Learning Objectives
- To develop an understanding of simultaneity and the measurement of time
- To explore the pole-in-the-barn paradox
- To explore space-time diagrams.

Procedure
All of the materials for this laboratory can be found on the web. Start at the page:

http://webphysics.davidson.edu/physlet_resources/special_relativity/

Work your way through the 5 links labeled “Illustrations.” After you have worked your way through these, then complete the 3 exercises on the following web site:

http://webphysics.davidson.edu/physlet_resources/special_relativity/relativity.htm

You can fill in your answers as you work through these on the worksheets provided.

Turn in
Your worksheets.
Worksheet for Make-up Lab: Special Relativity
Make sure to include the correct units for every value given.
Use backside of sheet if you run out of room for comments

Illustrations:

#1 – notes:

#2 – notes:

A) How do the clock readings change as you vary the x position of the viewer?

B) How do the clock readings change as you vary the z position of the viewer?

C) Where does a viewer need to be located in order for the clocks to appear (approximately) synchronized?

#3 – notes:

#4 – notes:

#5 - notes:
Exercises:

#1 – Light Clocks:

a) Why can we do this? In other words, how is the conversion accomplished and what does it depend on? Compute the time interval between successive ticks.

b) Given Einstein's postulate about the constancy of the speed of light, what can we say about the ticking of the moving clock (as seen by the stationary observer) relative to the ticking of the stationary clock?

c) How fast must the moving clock travel to tick at one half the rate of the stationary clock? Use the animation above to check your answer.

d) Along the axis of motion, how long is the moving clock (as seen from the stationary frame) relative to the length of the stationary clock? Why is this modification necessary? In other words, if the length of the moving clock were unchanged, would we get consistent results?

#2 – Space-Time Diagrams:

a) What is the speed of the woman in Animation 1?

b) How does the representation of motion in Animation 2 differ from that in Animation 1?
c) Describe the motion of the woman through space-time in Animation 3.

d) Next, try a v / c of 0.9. What does her "trajectory" or "world-line" on the space-time diagram look like now?

e) Finally, try a v / c of -0.9. What has changed in this case?

f) What do these lines represent? Can objects have world-lines below these lines? Explain.

### 3 – Pole in a Barn:

a) When marking the ends, what time-dependent condition must be satisfied to obtain the correct length? Explain.

### View from the Barn Questions:

b) How fast is the pole moving relative to the barn (measured in c)?)

c) What is 1/slope of the red and green world-lines, respectively? What does 1/slope represent in space-time diagrams?

d) What do events A, A', and B refer to? Which if any of these events are simultaneous in this reference frame?
View from the Pole Questions:

e) How fast is the barn moving relative to the pole (measured in c)?

f) How long is the pole in this reference frame? Why is it this long?

g) How long is the barn in this reference frame? Why is it this long?

h) What do events A', B, and B' refer to? Which if any of these events are simultaneous in this reference frame?

Finally:

i) Does an instant in time exist when the pole is completely inside the doors and they can be closed without catching the pole? Of course, you would need to reopen the doors very quickly, but at least momentarily, could you have the contracted pole entirely enclosed between the barn doors? Explain your reasoning by referring back to the first question in this exercise and your ensuing observations.