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**Pole and Barn Lab**

**Physics 205**

**Prof. Singal**

(adopted from M. Trawick)

A pole vaulter named Anna runs with her 10 meter long pole at 0.8c in the positive x direction. She runs into an 8 meter-long barn, which has doors on both sides. The right end of the pole enters the barn at x = 0, at some time t < 0, and the left end of the pole enters the barn at x = 0 and t = 0.

Here’s what happens, according to farmer Bob, standing inside the barn:

- The pole is Length contracted so that it’s shorter than the barn.

- When the pole is centered inside the barn, Bob pushes a button so that both doors shut very quickly with the pole entirely inside the barn.

- Bob says, “Ah-ha! I’ve closed Anna’s pole inside the barn.”

But here’s what happens according to Anna:

- Her pole is 10 meters long.

- The barn is Length contracted to less than 8 meters long.

- Anna says, “My pole couldn’t possibly have been closed inside the barn!”

This is an apparent paradox.

Open the file pole\_and\_barn.nb in Mathematica. The file is under “labs” in Blackboard. If you get a pop-up error message, you may need to click “Enable Dynamic Content”. Type Ctrl-A to select all lines, and hit Shift-Enter to execute them. The graph you see represents a “spacetime diagram” (or “Minkowski diagram”) of this set of events, with x on the horizontal axis and t on the vertical axis.

1. With the velocity slider set to *v* = 0 (the default), the diagram is in the reference frame of farmer Bob. The red lines represent the positions in time (so-called “worldlines”) of the two barn doors, and the purple lines represent the positions in time of the two ends of Anna’s pole. Based on this diagram, what is the approximate length of Anna’s pole according to Bob?

2. Verify your answer in part 1 by doing a calculation to determine the precise length contraction of the pole according to Bob.

3. Now, move the slider so that you view these events from Anna’s reference frame.

From the graph, how long is the barn according to Anna?

4. Verify your reading of the graph in part 4 by calculating the precise length of the barn in Anna’s reference frame.

5. Now move the slider back to Bob’s reference frame. According to Bob, at what time is the pole exactly centered inside the barn?

6. There are two red dots in the graph at a random location. Edit the Mathematica file in the line that looks like

to change the coordinates (the *n* values) of those dots so that they mark the space and time coordinates of the closing of the two barn doors in Bob’s reference frame. What are those coordinates?

7. Describe the sequence of events in Bob’s reference frame (move upward in time). An event description would be something like “right end of pole passes open left barn door” (the first event).

8. Now move the slider back to Anna’s reference frame. Describe the sequence of events according to Anna. Hint: The first event is “left band door passes over right end of pole.”

9. So, was the pole ever closed inside the barn in either frame? Who has the ‘correct’ view —Anna? Bob? Neither? Both? (The resolution lies in the idea that different observers can measure different times and events that are simultaneous in one frame may not be simultaneous in another.)