Name: ______________________________
ID #: ______________________________

Physics 221 - Fall 2019
★ Homework ★
Chapter 4 & 5 - B

1) **4.3**

2) **4.6**

3) **4.9**

4) **4.11**

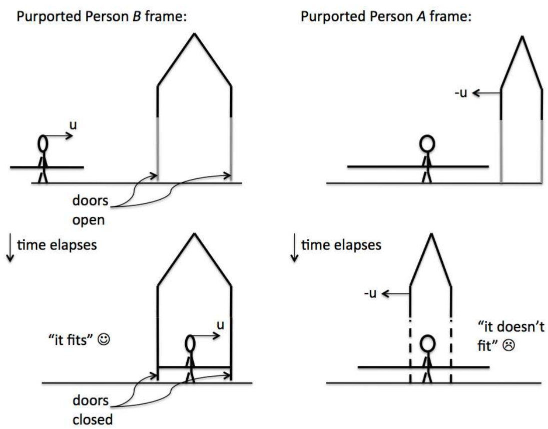
5) **5.1**

6) **5.3**

7) **5.5**

8) There is a famous 'paradox' in special relativity known as the 'Barn-Pole Paradox'. The basic setup is as follows (see figure): Person A carries a pole horizontally and runs (very fast - a significant fraction of the speed of light) *to the right* towards a barn which has a front door and a back door. Person B is stationary in the Earth (Barn) frame right next to the barn. Person B has a clicker that will instantly slam shut then reopen both barn doors at a push of the button (assume this happens instantly in the earth frame and neglect time for the signal to travel to each door). The barn is of length, b, as measured in the stationary Earth/barn/person B frame. Person A's pole is of such a length, p, such that in the stationary frame it is just a bit less that b (because of length contraction the pole must be larger than b in the runner's [person A's] own frame). As such, from the stationary (person B) frame there is an instant where person B could click the button, slamming shut both doors for an instant and trap the pole completely within the barn (pushed when the back of the pole just passes the front barn door).

Now the 'paradox': The runner (person A) argues that from their reference frame (moving frame), it is the barn that is length contracted not the pole, and therefore the pole is larger than the depth of the barn in this frame. Person A concludes that there is no way that the pole can fit within the barn and so if person B clicked the button to slam both doors for an instant, then inevitably at least one door will hit one end of the pole. This (naive) reading of the situation results in purportedly conflicting answers (see figure). Of course since paradoxes are impossible there is a flaw somewhere in the above logic. Something is incorrect / forgotten in the above discussion. Here you are to figure out what is missed, and therefore understand the resolution of this "paradox".



a) **Set up a space-time diagram from the stationary (person B) perspective. Label each axis and draw the light-cone line.** *In all the following sketches it is a must that you to sketch as carefully as you can, as close to "relative scale" as possible, and label clearly which plots correspond to which subpart.*

b) **On this diagram, draw the world lines for the front and back of the barn. Please align the front of the barn with the $x = 0$ location when $ct = 0$.**

c) **Add to the same space-time diagram, the world lines of the front and back of the pole. Please align the front of the pole with the front of the barn at $ct = 0$.** [I have not specified the relative velocity, u, of the runner, so you may choose a reasonable slope.]

d) **Label the $ct^{'}$ axis for the front of the pole and add to your plot its corresponding $x^{'}$ axis.**

e) **Label the following events: i) when the front of the pole is at the front door of the barn, ii) when the back of the pole is at the front door of the barn, iii) when the front of the pole is at the back door of the barn, and iv) when the back of the pole is at the back door of the barn.**

f) **By looking at the order of these events as measured in each frame, explain the resolution of the paradox.**