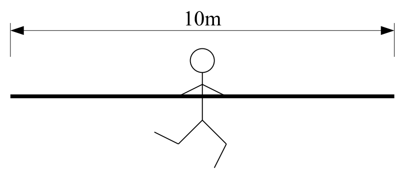
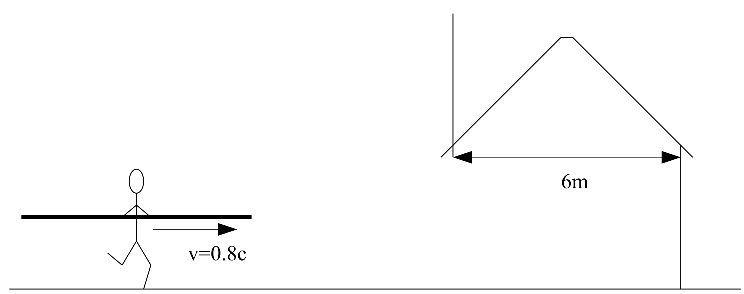
Astro 260
Group Problems #3
2005-February-04

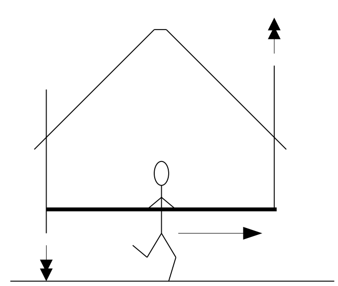
1. Consider the classic “pole valuter in a garage” relativistic paradox. A pole valutercarries a 10m long rigid pole.



There is a garage which is 6m wide. It has a door on the front and a door on the back. In the frame of reference of the garage, the pole valuter is running at 0.8c.



The garage is programmed so that once the back edge of the vaulter’s pole is inside the garage, the front door will instantly slam shut, and the back door will instantly slam open.



(a) Show that the Lorentz contraction of the pole vaulter is enough that the pole vaulter fits entirely in the garage, and no smashing of poles or doors need happen.

(b) In the pole vaulter’s frame, the garage is moving at 0.8c, and thus the *garage* is Lorentz contracted. Clearly the 10m pole will never fit within a 6m garage that is now less than 6m thanks to a Lorentz contraction. Yet we already know that there’s no smashing of poles or doors. How can this situation be resolved?

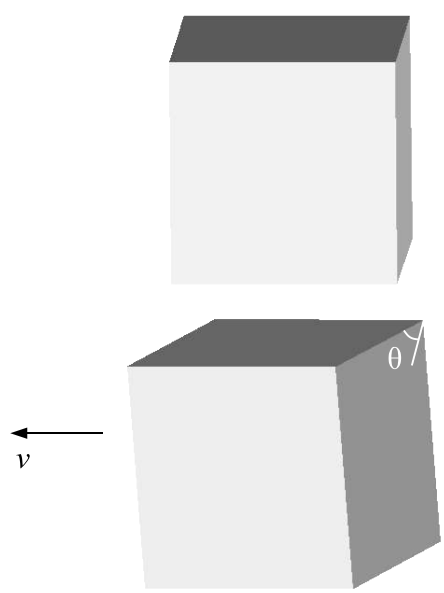
(c) Show mathematically that the resolution you suggested in part (b) works.

(d) Draw a spacetime digram. Draw it big, because lots of stuff will be on it. Include in the spacetime diagram each of the following:

- the worldline of the front of the garage;
- the worldline of the back of the garage;
- the worldline of the front of the pole;
- the worldline of the back of the pole;
- the event that is the front of the pole about to leave the garage;
- the event that is the back of the pole entering the garage;
- explicit lines and notations to show the width of the pole in the garage's frame, the width of the garage in the pole vaulter's frame, and what is happening at the same time as what else.

2. (*Hartle 4.2*) A rocket ship of proper length L leaves the Earth vertically at speed $\frac{4}{5}c$. A light signal is sent verticall after it which arrives at the rocket's tail at $t = 0$ according to both rocket and Earth-based clocks. When does the signal reach the nose of the rocket according to (a) the rocket clocks; (b) the Earth clocks? (If you know too much, ignore gravitational time dilation for this problem.)

3. (*Hartle 2.19*) If a photograph of an object moving uniformly with a speed approaching the speed of light parallel to the plane of the film, it appears rotated rather than contracted in the photograph. Explain why. (Assume the object subtends a small angle from the camera lens.)



By what angle θ would you calculate that it is rotated? Is the rotation as drawn in the image above in the correct direction?