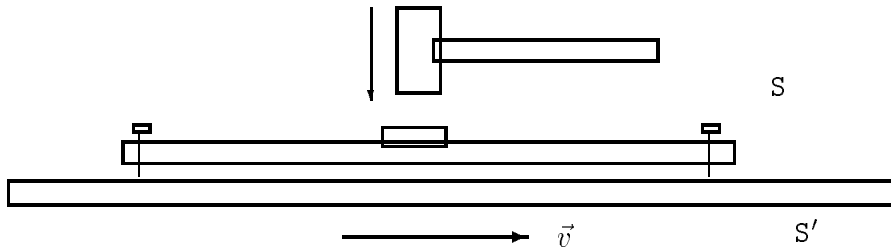


Physics 139 Relativity
 Problem Set 2 Due February 1, 2002

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1 Point of View:

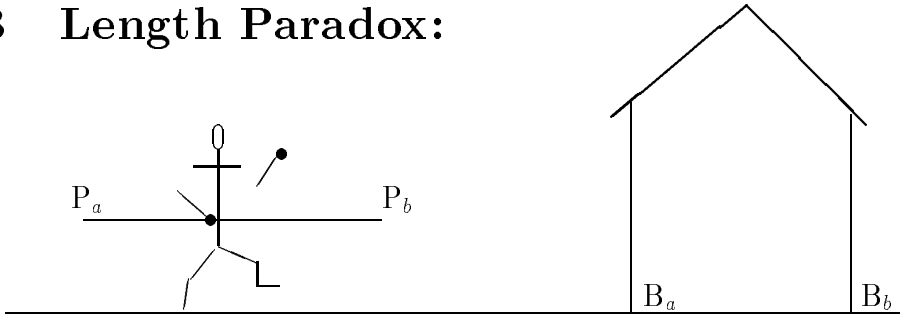


Observer O in system S places nails at the end of a meter stick resting along his x axis, and strikes it at its midpoint in the y direction at $t = 0$, knocking it toward a rod of greater length which is moving at velocity V in the x direction. The two nails leave two matching marks on the moving rod at the same time. Observer O claims that Observer O', moving with the second rod in system S', will ascribe a greater distance ℓ' than one meter to the separation between the marks on his rod, because he uses a contracted meter stick with which to measure the separation. Further, O claims that O' will ascribe a time difference $\Delta t'$ between the appearance of the marks, arising from the view of O that O' is using clocks that are out of synchronization. Assume that the hammer's causal impulse in the first rod moves with speed c from its midpoint to each end. Determine how O' views the calculation of O regarding ℓ' and $\Delta t'$. Establish full consistency.

2 Time Dilation:

A rocket ship of proper length 10 m moves away from the Earth at speed $4c/5$. A light signal is sent to the rocket that arrives at the rocket's tail at time zero according to the rocket clocks *and* Earth clocks. Calculate in both coordinate systems the time at which the light signal reaches the head of the rocket. There it is reflected back by a mirror. Calculate in both frames the time at which the light signal again reaches the tail of the rocket. Compare the elapsed times in the two frames of the round trip tail-to-head-to-tail by the light.

3 Length Paradox:



a thought experiment: a man running with speed $\sqrt{3}c/2$ carries a horizontal pole having a length of 20 m in his frame. On the ground is a barn 10 meters long in that frame and is open at both ends, through which the runner proceeds. Compute the length of the barn in the runner's frame S' . Call the front and back ends of the pole P_a and P_b , and the entry and exit ends of the barn B_a and B_b , respectively. Set event (0) to be when the first end of the pole, P_b , meets the entrance to the barn, B_a , and make that the origin of each coordinate system $(t, x) = (0, 0)$, and $(t', x') = (0, 0)$. Find in both frames the times and positions of the following events: (1) P_b meets B_b ; (2) P_a meets B_a ; (3) P_a meets B_b find the coordinates (t, x) and (t', x') for each event. Discuss in both frames S and S' the layman's question: "Does the pole fit in the barn?"

4 Simultaneity

An event A occurs at $(ct, x, y, z) = (0, 0, 0, 0)$. Another event B occurs at $(3, 3, 4, 0)$ cm. (Light speed $c = 3 \times 10^{10}$ cm/sec.) Find a frame S' in which B precedes A in time by 1×10^{-10} sec. Is there a frame in which B and A occur at the same time? Suppose $ct_B = 6$ cm instead of 3 cm. Discuss the possibilities of bringing the events into spatial and temporal coincidence.

5 Constant Acceleration

If a rocket has constant acceleration in its rest frame of $g = 32$ ft/sec², how long does it take to get to a velocity of $c/\sqrt{2}$ with respect to the Earth? Give the answer both in proper time and Earth time. Neglect the acceleration of the Earth, and gravitational fields.

6 Rocket Science

In tests on the ground it is found that the rate of fuel consumption is proportional to the thrust, the constant of proportionality being 0.004 pound of fuel per second per pound of thrust. If the ratio of initial mass to residual mass after burnout is 10, for how long can acceleration equal to g be maintained? Consider the possible use of a multi-stage system to get to relativistic speeds.