Relativity **Classwork 1** 02Dec04

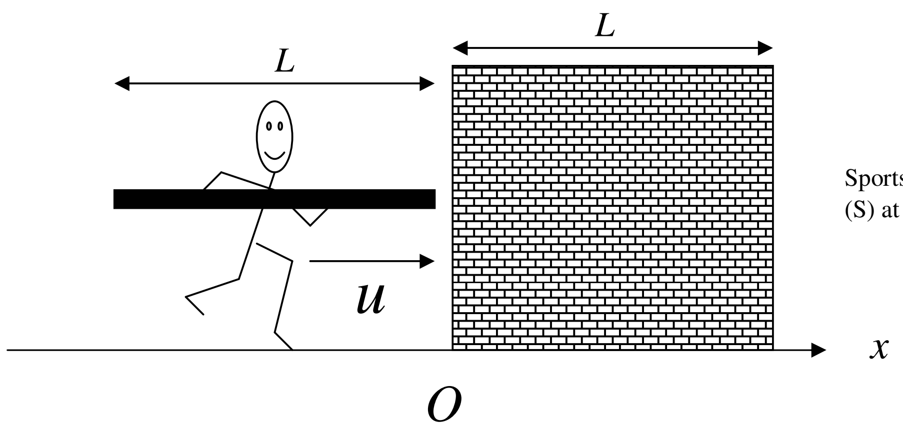
The perils of Paul:

This problem is an old one; the Pole and Barn 'paradox'. The aim is to convince yourselves at the end of the classwork that there is in fact no paradox. Prof. Keith Barnham is acknowledged for adding the local flavour.

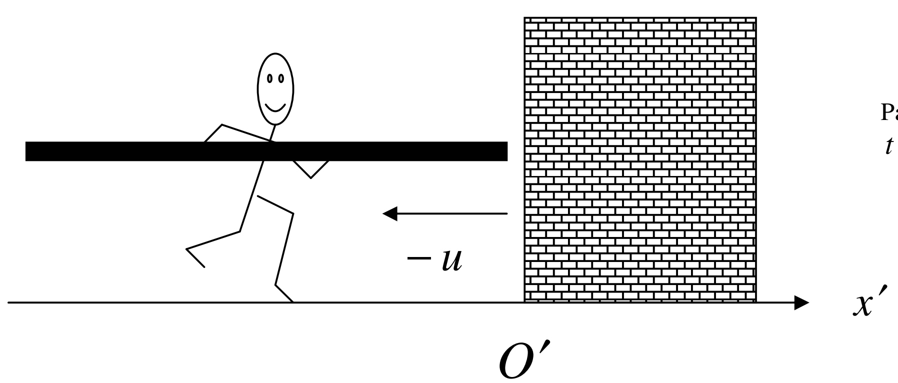
Paul Volta, the RCS champion pole-vaulter, has a pole 20m long. His run-up is so fast that his pole appears contracted to a length of only L=10m. To achieve such a speed he needs a long run-up and he has to pass through the changing rooms, which are just over L=10m long. In an attempt to remove him from the competition, Guilds engineers install a photocell system, designed to close both entrance and exit doors at the instant when the *front* end of this pole reaches the *exit* door, with obvious disastrous consequences.

Fortunately the physicists hear of this dastardly plot. Though they cannot disconnect the device or prevent the doors closing, those who have done the electronics section in the laboratory devise another system which rapidly reopens the doors allowing Paul a free run.

Paul is told all this and is quite relaxed, until be begins his run-up towards the changing room, when he is dismayed to observe it has contracted. Too busy training to have attended the first year relativity lectures he worries about losing his title, his reputation and 15 metres of pole.



Sports ground frame (S) at $t = 0$



Paul's frame (P) at $t' = 0$

1. From the fact that the pole appears contracted to 10 m calculate the value of γ. Hence calculate Paul's speed, u.
2. Calculate the length of the changing room according to Paul.

Take as origin of coordinates and time, the event O, where the *front* of the pole reaches the *entrance* door of the changing room.

3. Write down expressions (in terms of L, the length of the changing room in the sports ground frame, and u, the relative speed between the frames) for the space-time coordinates in the sports ground frame (*S*) of the following events:
   (F) The *front* end of Paul's pole reaches the *exit* door.
   (B) The *back* end of Paul's pole reaches the *entrance* door.
4. Use the Lorentz Transformation equations to obtain expressions for space-time coordinates (in terms of L and u) of these same events in Paul's frame (*P*).
5. Calculate the times t_F, t_B, t'_F and t'_B in *nanoseconds*. (t' refers to time as measured in Paul's frame).
6. Compare the values of t'_F and t'_B obtained from qu. 5. What can you say about Paul's chances?

If time permits

7. On a graph (space-time diagram) of t vs. x (with the time axis vertical), one for each frame, plot the trajectories of the entrance and exit doors, the front and back of the pole and the coordinates of the events O, F and B.

Answers to numerical questions:

1. $2, 2.6\times10^{8}\ ms^{-1}$.
2. $5m$.
5. 38.5, 38.5, 19.2 and 77.0 ns
6. Good.