

SET 5–DUE 18 FEBRUARY

“The ideas of space and time which I wish to develop before you grew from the soil of experimental physics. Therein lies their strength. Their tendency is radical. From now on, space by itself and time by itself must sink into the shadow, while only a union of the two preserves independence.” – H. Minkowski (1908)

1) [10 points] Jackson 11.4 (a)–5 points, (b)–5 points. You may need to invoke length contraction at some point.

2) [10 points] Consider a stick with a mechanism which, in its proper rest frame, can simultaneously release a drop of ink from each end. The stick moves parallel to its length with a velocity v along the floor. When the mechanism is set off, how far apart (in the rest frame of the floor) are the marks on the floor? Justify your result from the point of view of an observer in the rest frame of the stick and an observer in the rest frame of the floor.

3) [15 points] Consider a stick with a mirror on the right end. At a given moment a photon and a particle moving with velocity $u < c$ leave the left end, moving to the right along the stick. The photon reaches the mirror first, is reflected, and, moving back to the left, encounters the particle still moving to the right, a fraction x of the way along the stick. The situation at three typical moments is shown below.

Using the fact that x is an invariant quantity (think about it!) show using only the constancy of the speed of light (i. e. you don't have to assume anything about the shrinking factor for the moving stick) that for an observer moving to the left with velocity v with respect to the stick, the velocity of the particle must be

$$w = \frac{u + v}{1 + \frac{uv}{c^2}}$$