



Figure: Minkowski space in which observer A is at rest and flashes a light signal at observer B, who moves with speed $4/5$, and flashes the signal back (here we use units of seconds [s] and $c = 1$ for the speed of light).

Special and General Relativity (PHZ 4601/560 Fall 2018) Midterm October 17.

1. Light signals and travel in two inertial frames: (50%).

In the above figure Minkowski space is parametrized by the coordinates of the rest frame S of an observer A. While observer A stays at rest, observer B moves with speed $\beta = 4/5$ along the positive x axis. At their common origin both, A and B, have set their clocks to zero. After 15 [s] observer A emits at position A_1 , i.e. at $(15 [s], 0)$ a light signal which reaches observer B at position B_0 , who flashes it back at observer A, who receives it at position A_2 as drawn in the figure.

- Find the coordinates of A_1 in the rest frame S' of B, where the translational freedom is used so that the origins of the restframes of A and B agree at time $t = t' = 0$.
- Find the coordinates of B_0 in the rest frames S of A and S' of B.
- Find the coordinates of A_2 in the rest frames S of A and S' of B.
- Transform the above figure into the rest frame S' of B.

Turn over to backside.

2. Spacetrip (50%).

- (a) Assume that the earth is in an inertial frame. A spaceship leaves the earth at time 0. The spaceship is constructed so that it has an acceleration g in each of its own instantaneous rest frames. By its own clock, it accelerates on a straight-line path for 1 year, decelerates at the same rate for 1 year, turns around, accelerates for 1 year, decelerates for 1 year, and lands on earth. Calculate the time on earth at the landing.

Instructions: Use $g = 9.81 \text{ [m/s}^2\text{]}$, one year = $365 \times 24 \times 3600 \text{ [s]}$ and for the speed of light $c = 300,000 \text{ [km/s]}$. State the result in units of years and decimal fractions of years to at least three significant digits.

- (b) How far away from Earth did the spaceship travel? Express the result in light years.