

Solutions

2.1 B Length in a frame is the endpoint separation at equal time in that frame; $\Delta t=0$ in the lab gives $L=L_0/\gamma$.

Compare the rejected options: simultaneously in the rod rest frame; at the same lab position at different times; at equal rod-frame times only; without any simultaneity condition. Use the stated model and conditions.

2.2 B $(0.5+0.5)/(1+0.25)=0.8$; the denominator keeps the result below c .

Compare the rejected options: $0.75c$; $0.9c$; $1.0c$; exactly c . Use the stated model and conditions.

2.3 $2/3$. Set $\Delta t'=0$ in $t'=\gamma(t-vx/c^2)$: $v=c^2\Delta t/\Delta x=(600/900)c=2c/3$.

2.4 False. Spacelike order can swap between frames; only timelike or lightlike order is invariant.

3.1 Set $\Delta x' = \gamma(\Delta x - v\Delta t) = 0$, so $v = \Delta x/\Delta t = 0.5c$. The proper time is $\sqrt{\Delta t^2 - (\Delta x/c)^2} = \sqrt{3}$ microseconds. They are timelike separated, and every time-oriented inertial frame retains their order. Award velocity condition, speed, proper time and causal classification/order.