

1. A girl throws a baseball straight upwards at time  $t=0$ . She catches it at exactly  $t=3.0$  seconds.

A) Calculate the velocity of the ball as a function of time ( $0 \leq t \leq 3$  sec), from the girl's perspective. (Use  $g=10 \text{ m/s}^2$ . Ignore air resistance. This is simply a Physics 50 trajectory problem!)

B) Now imagine that you are watching this same event from a descending elevator, with glass walls. You are dropping at a constant speed of  $2 \text{ m/s}$ . Use your answer from part A to determine the velocity of the ball, as a function of time ( $0 \leq t \leq 3$  sec), from your perspective. You may use the Galilean transformations in Appendix I if you wish... Or just use common sense. (This is non-relativistic!)

C) Use your answer to part B to calculate the amount of time that you should see the ball in the air, \*without\* transforming back into the girl's reference frame. (Do this problem in \*your\* reference frame!) Does your answer make any sense? Why or why not? (If it doesn't make sense, keep working at it until it does!)

D) Parts A-C are just classical physics. Now use relativistic time dilation to figure out the actual time duration that you would see the ball in the air in part C. (The correction will be very small, so you'll have to use a Taylor expansion of the time dilation equation. Hint:  $(1+x)^a$  is about  $1+xa$  if  $x \ll 1$ .)

2. Alice travels from Earth to a planet 8 light-years away from Earth, travelling at a constant  $0.6c$ . How long does the trip seem to take, from Alice's perspective?

Work this problem two ways:

A) First do it from Earth's perspective, and use the time dilation equation to figure out what Alice's clocks are reading.

B) Then do the whole problem from Alice's perspective; if you're not getting the same answer, you're forgetting a crucial piece of relativistic physics.

3. Consider the light-clock below, with a clock-tick time of  $2L/c$  when the clock is at rest (the mirrors are a distance  $L$  apart when the clock is at rest). Prove that the clock-tick time is still described by the usual time-dilation equation (Eq. 2.19) when the entire clock is moving with a speed  $v$  in the SAME direction as the light; see figure below. (Hint: You will have to consider length contraction, and treat the right-moving light pulse separately from the left-moving light pulse.)

