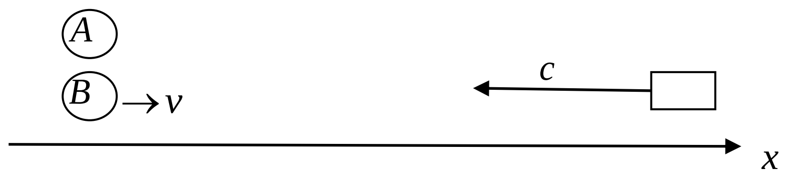
Homework 13 for GP1

Surely you may find problems can be solved by Lorentz Transform (the lecture may not have covered the transformation as this problem set is released), very often that is the systematic way and you shall master it.

However I shall encourage (not order) you solving the problems in this set without resorting to the L-Transform (as much as you can) by defining events and apply time dilation, length contraction etc., at least my answer key will not use it (but I shall include that for comparison sometimes). This is to let you develop the "feeling" for the fundamental effects of SR, instead of a "blind machine" only cranking the L-transform. You have more practices on appreciating the power of L-transform in later problem sets. (Of course you may resort to L-T transformation for the answer (that is probably the quick way)

Those marked with Optional means you may choose skipping them, and won't affect your exam.

1. KK 11.2 （12.4）
2. KK 11.4 （12.6）
3. **(Optional)** As the figure below shows. Two particles A,B: A is stationary in lab and B is moving with velocity v. A laser(also stationary in lab) is L (in lab frame) away from A. Viewed in lab frame, as A,B overlap, a light is simultaneously shoots out of the laser.



   a) In lab frame what is the time difference between particle B and particle A receives the light signal?
   b) If we are traveling with B with same speed v and in such frame, what is the time difference again? (Reminder: be careful of simultaneity here) Could the time order receiving signals by A,B reversed?
   c) If the laser is not shooting light but bullets with velocity V< c, of course B will be hit before A in lab frame. Could the time order of A,B hit by bullets be reversed for observers in another inertial frames? You may not have learned the materials from the lecture yet, (you will need velocity transformation or causality) ***take a guess*** for the present if you have no logical reason.
4. A train of proper length L and speed of 3/5 c approaches a tunnel of length L (proper length). When the head of the train enters the tunnel, a person leaves the head and starts running towards back. He arrives at the back at exactly same moment as the back of the train leaves the tunnel.
   (a) Do the simultaneity of the head (of the train) enters the tunnel and person starts running and the simultaneity of his arrival to the back and train leaves the tunnel depend on the frames of observation?
   (b) How much time does the process described above take in ground frame?
   (c) What is the speed of the person from the ground point of view?
   (d) How much time elapsed on the running person's watch?

5. A person runs with speed v towards a tunnel with proper length L. A laser is located at the far end of the tunnel. When the person enters the tunnel, the laser emits a photon simultaneously (in tunnel frame) towards the person. When the photon meets the person, the person has travelled xL, find the x value. Work this out in both frames of the tunnel and the person.
6. Alice and Bob start at same location at time 0 (both their watches read 0 when they meet), Alice travels right and bob towards left with relative speed v between them. When Bob's watch read T, he sends out a photon to Alice; when Alice receives the photon, what is time reading on her watch? Try this problems in both Bob's and Alice's frame. (The answer should of course be same no matter which frame you are using, because we are asking the time elapsed on Alice's watch. Test it in this problem)
7. Let Alice and Bob synchronize their watches at Starbucks and Bob immediately jumps on a bus with velocity v and travels with bus distance L (L in ground frame). Bob jumps off the bus and the reading of his watch will be different from proper synchronization (the watches of Alice and Bob will have different reading), calculate this difference and show that as v is small, the difference approaches 0.
8. ***(Optional)*** This problem is to illustrate the difference of measuring a moving rod length and seeing (really see with eyes) the length of the same rod: A rod with proper length L travels with v along the x direction (the rod is also aligned along x direction). The measured length for the lab frame is of course L/γ. Now imagine you are at the right of the whole rod and the rod is moving towards you from left, you are also standing close to the track of the motion of the rod. a) Explain that the lights which reaches your eyes at one time (the time your eyes record the picture, think your eye as a camera) must leaves the two ends of the rod at different times. b) from there, calculate the length as seeing by your own eyes, and show that it is different than L/γ, actually in this situation, it is even larger than L.(Here is quite analogous to Doppler effect we shall talk about)
9. ***(Optional)*** Is the cookie round or not: Suppose a cookie dough is on a conveying belt travelling with velocity v. A round cutter (in factory frame) with radius R will punch down repeatedly to cut the dough into cookies. Then when you buy the cookies in store, what is the shape of the cookie, a round one with radius R or elongated (or shortened) along one side? Explain this both in factory frame and in the cookie (on the conveying belt) frame. (The answer of course should not depend on the frames)