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Special Theory of Relativity
Second Semester
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Assignment 1

Due: Monday March 4, 2013

Q1: Consider two inertial frames S and S'. S is stationary while S' is moving relative to S at a constant speed u along the x-direction. Show that under Galilean Transformation, and for a collision between two masses, the linear momentum is conserved in the moving frame. Assume that the masses stay unchanged after the collision and the collision is one-dimensional.

Hint: Prove first the equivalence of the mass ratios $\frac{m_1}{m_2} = \frac{m_1'}{m_2'}$

Q2: For the two frames and processes given in Q1, show that the linear momentum is conserved (before and after the collision) in S', but in this case assume that the masses change in S frame from m_1, m_2 before collision to m_3 and m_4 after the collision. The same notation is a followed in the S' frame**.** i.e. m_1' and m_2' are changed to m_3' and m_4'.

Q3: For the two frames and processes given in Q1, show that the kinetic energy is conserved in the S' frame if the collision is elastic.

Q4: Using matrix notation, write down the transformation matrix for Galilean Transformation for the two 4-vectors (x, y, z, ct) and (x', y', z', ct') between the two frames as defined in class. By finding the inverse matrix, show that the inverse Galilean Transformation is also valid.

Q5: A driver in a boat wishes to row across a river to a point directly opposite as shown in Figure 1. The width of the river is 10 m. She can row at 2 m/s in still water and the river is flowing at 1 m/s. Find the time t_1 needed for the driver in a round trip. A second driver in another boat, with the same speed of 2 m/s in still water wishes to go downstream for 10 m and then turn back and row upstream to the initial point. Find the time t_2 needed for the round trip of the second driver. Which is longer, t_1 or t_2.