Physics 201: Assignment #1

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Due: Feb. 1, 2013

1. An application of the Galilean transformation and Newtonian relativity is the *centre of mass frame*. Don't need to use special relativity for this problem.

   (a) Suppose that an alpha particle has a kinetic energy of 8.0×10^{-13} J as measured in the S frame. The mass of an alpha particle is 4.00 u (unified mass units, see the back cover of the book). What is the speed of the α particle? Is it much less than c? (2)

   (b) Now we will consider a head-on, 1-dimensional collision with an aluminum nucleus ($m_{\mathrm{Al}} = 27.0$ u) that is at rest in the S frame. The frame S' does not move with the α particle but instead moves at "centre of mass" velocity

   $$v = \frac{m_\alpha u_{x\alpha} + m_{\mathrm{Al}} u_{x,\mathrm{Al}}}{m_\alpha + m_{\mathrm{Al}}} \tag{1}$$

   Calculate the centre of mass velocity and then use the Galilean transforms to give $u'_{x,\alpha}$ and $u'_{x,\mathrm{Al}}$. (4)

   (c) Numerically calculate p'_x for the system and also show symbolically that $p'_x = 0$. (4)

   (d) Why all of this work? Because the collision in the S' frame conserves energy and momentum and because $p'_x = 0$ the final primed velocities are just the negatives of the intial primed velocities (they "bounce" off each other). Use inverse Galilean transforms to calculate the final velocities in the S frame and show the kinetic energy in this frame is still 8.0×10^{-13} J. (4)

2. Tipler 1-24 (same in the 5th edition) In addition include a space-time diagram that shows the event of the typical pions decaying and how it would be graphically interpreted. (12 points)

3. Tipler 1-10 (same in 5th edition). (10 points)

   Note that the order of A, B and C is not the same as it was in the relativity of simultaniety explanation; B is now in the middle. If you want put A on the right and C on the left.

4. Tipler 1-50 (I think this is the same as 1-49 in the 5th edition. Might be able to look up the answers.) (10 points)