General Physics 204, Section ... Monday, Apr 13, 2015

Quiz #9 Special Relativity

Name:

Earth's frame:

event 1. $(t_1^E = 0,\ x_1^E = 0)$

event 2. $(t_2^E,\ x_2^E = 20\,ly)$

Spaceship's frame:

event 1. $(t_1^S = 0,\ x_1^S = 0)$

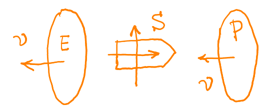
event 2. $(t_2^S,\ x_2^S = 0)$ $t_2^S$ : proper time

**1) CLASS(2)**

Hendrick Lorentz is 52 years old and starts to travels to another close planet which is 20 ly away. The spaceship velocity is $9c/10$. How old is he when he arrives to the other planet? **[4 pts]** $1\,ly = 1\,c\,y$

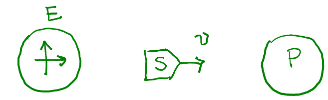
Spaceship frame of ref. : $L = L_0\sqrt{1-\frac{v^2}{c^2}} = 20\,ly\sqrt{1-\frac{9^2}{10^2}} = 2\sqrt{19}\ ly$

$\rightarrow \Delta t_0 = \dfrac{2\sqrt{19}\ ly}{\frac{9}{10}c} = \dfrac{20\sqrt{19}}{9}\ y = t_2^S.$




Earth/planet frame of ref.: $L_0 = 20\ ly \rightarrow \Delta t = \dfrac{20\ ly}{\frac{9}{10}c} = \dfrac{200}{9}\ y = t_2^E$

$\Delta t = \dfrac{\Delta t_0}{\sqrt{1-v^2/c^2}} \rightarrow \Delta t_0 = \dfrac{20}{9}\sqrt{19}\ y = t_2^S.$



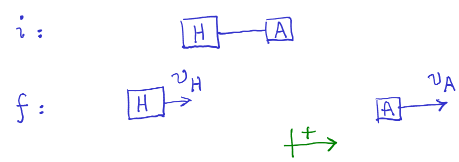

H. L.'s age $= 52 + \dfrac{20\sqrt{19}}{9}\ y$

**2) CLASS(2)**

Henri Poincarè and Albert Einstein are on top of the ice. Take their rest masses to be $m_H = 3/2 m_A$. The surface of the ice is frictionless and the speed of light is $c = 3$ m/s. As they were standing at rest, they push each other away. We know $v_A = 9c/10$. Find $v_H$. **[6 pts]**

There is no external force in horizontal direction

$F_{ext} = \dfrac{\Delta P}{\Delta t} = 0$




$\longrightarrow P_i = P_f$ (momentum is conserved).

$$\begin{cases} P_i = 0 \\ P_f = \dfrac{m_A v_A}{\sqrt{1-\frac{v_A^2}{c^2}}} + \dfrac{m_H v_H}{\sqrt{1-\frac{v_H^2}{c^2}}} \end{cases} \rightarrow \dfrac{m_A v_A}{\sqrt{1-\frac{v_A^2}{c^2}}} + \dfrac{m_H v_H}{\sqrt{1-\frac{v_H^2}{c^2}}} = 0$$

$$\rightarrow \dfrac{m_A^2 v_A^2}{1-\frac{v_A^2}{c^2}}\left(1-\frac{v_H^2}{c^2}\right) = m_H^2 v_H^2 \rightarrow$$

$$v_H = -c\left[1+\frac{m_H^2}{m_A^2}\left(\frac{c^2}{v_A^2}-1\right)\right]^{-1/2}$$

$$= -3\left[1+\frac{9}{4}\cdot\frac{19}{81}\right]^{-1/2}$$

$$= -\frac{18}{\sqrt{55}}\ m/s.$$

Kinetic energy is clearly not conserved:

$KE_i = 0$

$$KE_f = m_A c^2\left(\frac{1}{\sqrt{1-\frac{v_A^2}{c^2}}}-1\right) + m_H c^2\left(\frac{1}{\sqrt{1-\frac{v_H^2}{c^2}}}-1\right) > 0.$$

$KE_f$ = Interaction Energy $\neq 0$.