tutorial #11 [special relativity] .quiz

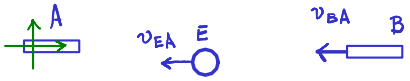
1) A person on earth notices a rocket approaching from the right at a speed of $0.75c$ and another rocket approaching from the left at $0.65c$. What is the relative speed between the two rockets, as measured by a passenger on one of them?

$$v_{BA} = \frac{-0.75c - 0.65c}{1 + (-.65)(-.75)}$$

$$= -.94c .$$

person on earth frame of ref. :

rocket A frame of ref. :



$$v_{EA} = \frac{0 - 0.65c}{1 + \frac{0 \times -.65c}{c^2}} = -.65c .$$

2) Twins who are 19.0 years of age leave the earth and travel to a distant planet 12.0 light-years away. Assume that the planet and earth are at rest with respect to each other. The twins depart at the same time on different spaceships. One twin travels at a speed of $0.900c$, and the other twin travels at $0.500c$.
a) According to the theory of special relativity, what is the difference between their ages when they meet again at the earliest possible time?
b) Which twin is older?

a) Twin A : time an observer on planets measure for travel $= \Delta t_1 = \frac{12\ ly}{0.900c} = 13.3$ years

A's clock passed $\Delta t_0 = \frac{13.3\ y}{\gamma} = \sqrt{1 - .900^2}\ 13.3y = 5.8\ y$ (proper time)

Twin B : " " " " " " " " $= \Delta t_1 = \frac{12\ ly}{0.500c} = 24.0$ years

B's clock passed $\Delta t_0^B = \frac{24.0}{\gamma} = \sqrt{1 - .500^2}\ 24.0\ y = 20.8\ y$

Twin A aged $5.8 + (24.0 - 13.3) = 16.5\ y$ when twin B joins A at distant planet. Twin B aged $20.8y$.

b) Twin B will be $4.8y$ older.

3) An unstable particle is at rest and suddenly breaks up into two fragments. No external forces act on the particle or its fragments. One of the fragments has a velocity of $+0.800c$ and a mass of 1.67×10^{27} kg, and the other has a mass of 5.01×10^{27} kg. What is the velocity of the more massive fragment? *hint: momentum conservation.*

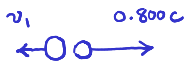
in the rest frame of unstable particle

before breaking $p = 0$ so after breaking

$p = p_1 + p_2 = 0$,

$$\rightarrow -\frac{5.01 \times 10^{27}}{\sqrt{1 - v_1^2/c^2}}\, v_1 + \frac{1.67 \times 10^{27} \times .800c}{.600} = 0$$

$$\rightarrow v_1 = 0.41c .$$



$$p_1 = -\gamma_1 m_1 v_1 = \frac{5.01 \times 10^{27} \cdot v_1}{\sqrt{1 - \frac{v_1^2}{c^2}}}$$

$$p_2 = \gamma_2 m_2 v_2 = \frac{1.67 \times 10^{27} kg \cdot 0.800c}{\sqrt{1 - .800^2}}$$