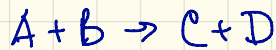


15.2



Galileo transform:

$$m_A \vec{v}_A + m_B \vec{v}_B = m_C \vec{v}_C + m_D \vec{v}_D$$

$$\vec{v} = \vec{v}' + \vec{V}$$

$$0 = \underbrace{m_A \vec{v}'_A + m_B \vec{v}'_B - m_C \vec{v}'_C - m_D \vec{v}'_D}_{=0 \text{ if momentum conserved in } K'} + (m_A + m_B - m_C - m_D) \vec{V}$$

$= 0$ if momentum conserved
in K'

Since \vec{V} is arbitrary,

$$m_A + m_B - m_C - m_D = 0$$

$$m_A + m_B = m_C + m_D$$

\uparrow
mass conservation!

15.3

$$v = 8 \cdot 10^3 \text{ m/s}$$

$$c = 3 \cdot 10^8 \text{ m/s}$$

$$\frac{v}{c} = 2.66 \cdot 10^{-5}$$

$$\gamma = \frac{1}{\left(1 - \frac{v^2}{c^2}\right)^{1/2}} \approx 1 + \frac{v^2}{2c^2} = 1 + 3.6 \cdot 10^{-10}$$

$$3.6 \cdot 10^{-10} \cdot 3.6 \cdot 10^3 \text{ s} \approx 13 \cdot 10^{-7} = 1.3 \cdot 10^{-6} \text{ s} = 1.3 \mu\text{s}$$

clock on the satellite would show
1 hour - 1.3 μs.

15.5

$$\beta = 0.95: \gamma = \frac{1}{\sqrt{1-0.95^2}} \approx 3.2 \leftarrow \text{same for trips there and back}$$

$$\Delta t = 80 \text{ years}$$

$$\Delta t_{\text{there}} = 40 \text{ years}$$

$$\Delta t_{\text{back}} = 40 \text{ years}$$

$$\Delta t'_{\text{there}} = \frac{\Delta t_{\text{there}}}{\gamma}$$

$$\Delta t'_{\text{back}} = \frac{\Delta t_{\text{back}}}{\gamma}$$

$$\Delta t' = \frac{\Delta t}{\gamma} \approx 25 \text{ years}$$

\leftarrow clocks on A say that's how long the trip took

\rightarrow twin A is $80 - 25 = 55$ years younger.

15.7

$$\tau = 1.5 \mu\text{s (proper)} \quad h = 2 \cdot 10^3 \text{ m}$$

$$v = 0.99c \rightarrow \gamma = 7.1$$

$$\tau_{\text{earth}} = \gamma \tau \quad \leftarrow \text{moving } \mu \text{ live longer}$$

Time to Earth

$$t = \frac{h}{v}$$

$$N = N_0 \cdot 2^{-t/\tau}$$

$$N_{\text{classical}} = N_0 \cdot 2^{-\frac{h}{v\gamma\tau}} = 650 \cdot 2^{-0.63} = \underline{\underline{420}}$$

$$N_{\text{true}} = N_0 \cdot 2^{-\frac{h}{v\tau}} = 650 \cdot 2^{-4.5} = \underline{\underline{29}}$$

15.8

$$\tau = 1.8 \cdot 10^{-8} \text{ s}$$

$$a) \tau(0.8c) = \tau / \sqrt{1 - 0.8^2} = \tau \cdot \frac{1}{0.6} = 3 \cdot 10^{-8} \text{ s}$$

b) time of flight

$$t = \frac{d}{0.8c} \quad N = N_0 \cdot 2^{-\frac{d}{0.8c} \frac{0.6}{\tau}} = 32000 \cdot 2^{-5} \approx 1000$$

$$c) N_{\text{classical}} = N_0 \cdot 2^{-\frac{d}{0.8c} \frac{1}{\tau}} \approx 32,000 \cdot 2^{-8.3} \approx 100$$