

77. (a) The relative contraction is

$$\begin{aligned}
 \frac{|\Delta L|}{L_0} &= \frac{L_0(1 - \gamma^{-1})}{L_0} = 1 - \sqrt{1 - \beta^2} \\
 &\approx 1 - \left(1 - \frac{1}{2}\beta^2\right) = \frac{1}{2}\beta^2 \\
 &= \frac{1}{2} \left( \frac{630 \text{ m/s}}{3.00 \times 10^8 \text{ m/s}} \right)^2 \\
 &= 2.21 \times 10^{-12} .
 \end{aligned}$$

(b) Letting  $|\Delta t - \Delta t_0| = \Delta t_0(\gamma - 1) = \tau = 1.00 \mu\text{s}$ , we solve for  $\Delta t_0$ :

$$\begin{aligned}
 \Delta t_0 &= \frac{\tau}{\gamma - 1} = \frac{\tau}{(1 - \beta^2)^{-1/2} - 1} \approx \frac{\tau}{1 + \frac{1}{2}\beta^2 - 1} = \frac{2\tau}{\beta^2} \\
 &= \frac{2(1.00 \times 10^{-6} \text{ s})(1 \text{ d}/86400 \text{ s})}{[(630 \text{ m/s})/(2.998 \times 10^8 \text{ m/s})]^2} \\
 &= 5.25 \text{ d} .
 \end{aligned}$$