Problem set 2 - Answers

September 29, 2025

I really need to still look over these and compare them to the way the problems are stated.

1. Time dilation:
   $\gamma = 1/\sqrt{1 - v^2/c^2} = 1/\sqrt{1 - 0.6^2} \approx 1.25$
   Earth time = $\gamma\times$ Spaceship time
   Earth time = 1.25 * 2 hours = 2.5 hours

2. The frames coincide at the first event.
   So the first event is at $t = 0$, $x = 0$ in both frames.
   $\gamma = \frac{5}{3}$ or about 1.67
   Lorentz transform the 2nd event, and it occurs at
   $t = 8.33$, $x = 6.67$ in the other frame.
   So the spatial separation is about $6.67\mu s$ or around 2,000 meters.
   Or you could dilate the time ...
   Then 8.33 seconds passes in the primed frame.
   And the distance traveled is x=vt $\approx$ (8.33)(.8) giving the same answer.

3. Length contraction:
   $L' = L/\gamma$
   $\gamma = 1/\sqrt{1 - 0.5^2} \approx 1.15$
   $L' = 1m/1.15 \approx 0.87m$

4. Time dilation for muon decay:
   $\gamma \approx 7.09$ (for v = 0.99c)
   Proper lifetime = 2.2 μs
   Dilated lifetime = $7.09 \times 2.2\mu s \approx 15.6\mu s$
   Distance = $0.99c \times 15.6\mu s \approx 4.63km$

5. Time dilation for light clock:
   Proper time between bounces = 2 seconds
   Dilated time = $\gamma\times$ 2 seconds
   $\gamma \approx 1.25(v = 0.6c)$
   Dilated time = $1.25 \times 2 = 2.5$ seconds
   Number of bounces in 10 seconds = 10 / 2.5 = 4 bounces

6. Time dilation to cause 2-second delay:
   This is a Lorentz transform problem.
   The correct answer is $\frac{2}{\sqrt{13}}$.

7. Length contraction:
   $L' = L/\gamma$
   $\gamma \approx 1.67 (v = 0.8c)$
   $L' = 100m/1.67 \approx 59.9m$

8. Relativistic velocity addition:
   v $= (v_1 + v_2)/(1 + v_1 v_2)$
   v $= (0.75 + 0.75)/(1 + 0.75 \times 0.75) \approx 0.96c$