PHYS 615 – Activity 15.2: Time Dilation, Length Contraction, Lorentz transform

1. *Ball in Train Car*

   Analogous to how we derived time dilation, let's do the same gedanken experiment for throwing up a ball from the train car's floor, which then hits the ceiling where it gets reflected back and hits the floor again a short time later.

   For simplicity, let's assume there is no gravity. Given the ball's vertical speed is $v_y = const$, and the height of the train car is h, what time $\delta t'$ does an observer in the train car measure?

   Now, let's do that calculation again from the ground, where the observer(s) stand still while the train goes by at a speed of V?

2. *Time Dilation*

   What is the factor γ for a speed of $0.99c$? As observed from the ground, by how much would a clock traveling at this speed differ from the ground-based clock after one hour (one hour measured by the latter, that is)?

3. *Rent-a-rocket*

   When he returns his Hertz rent-a-rocket after one week's cruising in the galaxy, Spock is shocked to be billed for a 3 week rental. Assuming he traveled straight out, and then straight back, always at the same speed, how fast was he traveling?

4. *Length Contraction*

   As a meter stick rushes past me (with velocity $\vec{v}$ parallel to the stick), I measure it's length to be 80 cm. What is v?

5. *Lorentz Transformation*

   Solve the Lorentz transformation equations

$$\begin{aligned} x' &= \gamma(x - Vt) \\ y' &= y \\ z' &= z \\ t' &= \gamma\left(t - \frac{V}{c^2}x\right) \end{aligned}$$

   to give x, y, z, t in terms of x', y', z', t'. Compare to what you would have obtained if you had swapped primed and unprimed quantities.