

Physics 203 Practice Problems - July 21st, 2022

1)

The current world record in the 100 metres for men (athletics) was set at 9.58 seconds by Usain Bolt in 2009.

- (a) From Usain Bolt's point of view there is a relativistic correction to the distance he ran. Calculate that correction assuming the entire sprint is at constant speed.

[Note: Your answer may seem small in the extreme, yet very small numbers are not always crazy; LIGO detects mirror displacements due to gravitational waves on the order of 10^{-18} m.]

[2 mark]

$$\text{His speed is } v = \frac{L}{\Delta t} = \frac{100 \text{ m}}{9.58 \text{ s}} = 10.4 \text{ m/s.}$$

In his frame he sees a contracted length $L' = \frac{L}{\gamma}$, so relativistic correction is

$$\begin{aligned} (\Delta L)_{\text{rel}} &= L - L' = (1 - \gamma^{-1})L = (1 - \sqrt{1 - \frac{v^2}{c^2}})L \\ &= (1 - (1 - \frac{1}{2} \frac{v^2}{c^2}))L \\ &= \frac{1}{2} \frac{v^2}{c^2} L = 6.0 \times 10^{-14} \text{ m} \end{aligned}$$

- (b) If relativity is considered, a clock carried by Usain Bolt would also disagree with the timing. Calculate the timing *difference*.

[2 mark]

His clock runs slower and records the time $\Delta t' = \gamma^{-1} \Delta t$.

Relativistic correction is

$$\begin{aligned} (\Delta t)_{\text{rel}} &= (1 - \gamma^{-1}) \Delta t \\ &= (1 - \sqrt{1 - \frac{v^2}{c^2}}) \Delta t \\ &= \frac{1}{2} \frac{v^2}{c^2} \Delta t = 5.75 \times 10^{-15} \text{ s.} \end{aligned}$$

- (c) In which frame of reference (Usain Bolt's or the stationary frame of the track) is the proper length measured (part (a)) and in which is the proper time measured (part (b))?

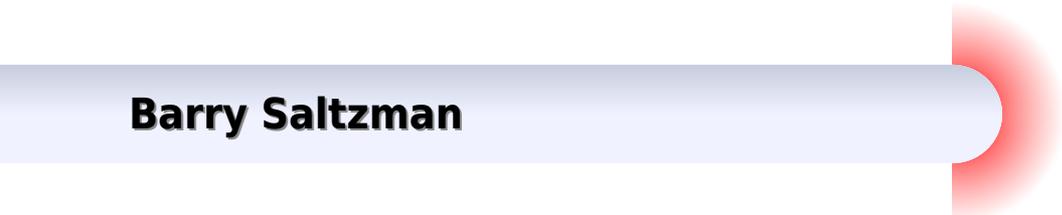
[1 mark]

Proper length measured in the frame of the track.

Proper time in Usain Bolt's frame (where start and finish are at the same point in space).

Special Relativity Practice Problems And Solutions

Barry Saltzman



Special Relativity Practice Problems And Solutions:

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