

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

Terry C. Jones



Special Relativity Practice Problems And Solutions:

Special Relativity Michael Tsamparlis, 2010-05-17 Writing a new book on the classic subject of Special Relativity on which numerous important physicists have contributed and many books have already been written can be like adding another epicyle to the Ptolemaic cosmology Furthermore it is our belief that if a book has no new elements but simply repeats what is written in the existing literature perhaps with a different style then this is not enough to justify its publication However after having spent a number of years both in class and research with relativity I have come to the conclusion that there exists a place for a new book Since it appears that somewhere along the way mathematics may have obscured and prevailed to the degree that we tend to teach relativity and I believe theoretical physics simply using heavier mathematics without the inspiration and the mastery of the classic physicists of the last century Moreover current trends encourage the application of techniques in producing quick results and not tedious conceptual approaches resulting in long lasting reasoning On the other hand physics cannot be done a la carte stripped from philosophy or to put it in a simple but dramatic context A building is not an accumulation of stones As a result of the above a major aim in the writing of this book has been the distinction between the mathematics of Minkowski space and the physics of relativity

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