

## Physics 203 Practice Problems - July 21<sup>st</sup>, 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

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

- (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

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

- (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

**Victor M. Corman**



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## **Table of Contents Special Relativity Practice Problems And Solutions**

1. Understanding the eBook Special Relativity Practice Problems And Solutions
  - The Rise of Digital Reading Special Relativity Practice Problems And Solutions
  - Advantages of eBooks Over Traditional Books
2. Identifying Special Relativity Practice Problems And Solutions
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Special Relativity Practice Problems And Solutions
  - User-Friendly Interface
4. Exploring eBook Recommendations from Special Relativity Practice Problems And Solutions
  - Personalized Recommendations
  - Special Relativity Practice Problems And Solutions User Reviews and Ratings
  - Special Relativity Practice Problems And Solutions and Bestseller Lists
5. Accessing Special Relativity Practice Problems And Solutions Free and Paid eBooks
  - Special Relativity Practice Problems And Solutions Public Domain eBooks
  - Special Relativity Practice Problems And Solutions eBook Subscription Services
  - Special Relativity Practice Problems And Solutions Budget-Friendly Options
6. Navigating Special Relativity Practice Problems And Solutions eBook Formats

- ePub, PDF, MOBI, and More
  - Special Relativity Practice Problems And Solutions Compatibility with Devices
  - Special Relativity Practice Problems And Solutions Enhanced eBook Features
7. Enhancing Your Reading Experience
    - Adjustable Fonts and Text Sizes of Special Relativity Practice Problems And Solutions
    - Highlighting and Note-Taking Special Relativity Practice Problems And Solutions
    - Interactive Elements Special Relativity Practice Problems And Solutions
  8. Staying Engaged with Special Relativity Practice Problems And Solutions
    - Joining Online Reading Communities
    - Participating in Virtual Book Clubs
    - Following Authors and Publishers Special Relativity Practice Problems And Solutions
  9. Balancing eBooks and Physical Books Special Relativity Practice Problems And Solutions
    - Benefits of a Digital Library
    - Creating a Diverse Reading Collection Special Relativity Practice Problems And Solutions
  10. Overcoming Reading Challenges
    - Dealing with Digital Eye Strain
    - Minimizing Distractions
    - Managing Screen Time
  11. Cultivating a Reading Routine Special Relativity Practice Problems And Solutions
    - Setting Reading Goals Special Relativity Practice Problems And Solutions
    - Carving Out Dedicated Reading Time
  12. Sourcing Reliable Information of Special Relativity Practice Problems And Solutions
    - Fact-Checking eBook Content of Special Relativity Practice Problems And Solutions
    - Distinguishing Credible Sources
  13. Promoting Lifelong Learning
    - Utilizing eBooks for Skill Development
    - Exploring Educational eBooks
  14. Embracing eBook Trends
    - Integration of Multimedia Elements
    - Interactive and Gamified eBooks

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