

5.1 Relativity and measuring events

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS proper time • inertial frame

Objective

Relativity and measuring events. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

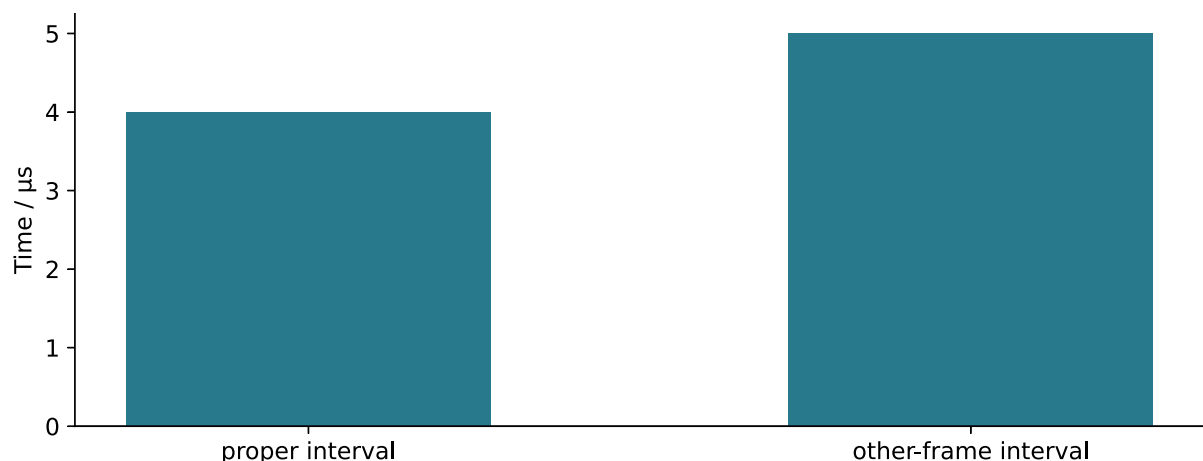
1 Key knowledge and worked examples

■ What would explain this observation?

- Two observers can assign different times between the same events. A clock reading has meaning only when the frame and events are specified.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ Build the model

- In special relativity, inertial observers measure the same vacuum light speed. Time dilation compares **proper time** measured where two events occur at one place with the interval in another **inertial frame**.
- proper time: Time between events measured at one location in a frame; inertial frame: A frame in which a free body moves at constant velocity.



■ Choose evidence that can test it

- The Lorentz factor is 1 divided by the square root of 1 minus speed squared over light speed squared. Galilean velocity addition is an approximation for speeds much smaller than light speed.
- Label which frame measures proper time or proper length before substituting. Use event coordinates consistently. Do not combine lengths from one frame with time intervals from another without transformation.

■ Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: $v = 0.60c$ and proper time is 4.0 microseconds. $\gamma = 1/\sqrt{1-v^2/c^2} = 1/\sqrt{1-0.60^2} = 1.25$. $\Delta t = \gamma\Delta t_0 = 1.25 \times 4.0 = 5.0$ microseconds in the stated second frame.

Example:

A proper interval is 8 microseconds and gamma is 1.25. Find the other-frame interval. Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ Check the conclusion and its limits

- Time dilation is not an instrument fault. Proper length is measured in the object rest frame; a contracted length is measured in a frame where it moves.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

All inertial observers must measure the same time interval between any two events. This claim is false: Time dilation is not an instrument fault. Proper length is measured in the object rest frame; a contracted length is measured in a frame where it moves.

Key:

Relativity and measuring events: The Lorentz factor is 1 divided by the square root of 1 minus speed squared over light speed squared. Galilean velocity addition is an approximation for speeds much smaller than light speed.

2 Practice

2.1 Where is proper length measured? Choose one answer.

- **A** In the object rest frame
- **B** Only in any fast-moving frame
- **C** In no frame at all

[1]

2.2 A proper interval is 8 microseconds and gamma is 1.25. Find the other-frame interval. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: All inertial observers must measure the same time interval between any two events. [2]

2.4 Time between events measured at one location in a frame: write the technical term. [1]

3 Exam-style questions

3.1 At $v=0.60c$, lab lifetime is 10 microseconds. Find proper lifetime and lab travel distance. Identify the proper clock. [4]

Solutions

2.1 A The Lorentz factor is 1 divided by the square root of 1 minus speed squared over light speed squared. Galilean velocity addition is an approximation for speeds much smaller than light speed.

2.2 $\Delta t = \gamma \times \text{proper interval} = 1.25 \times 8 = 10$ microseconds.

2.3 False. Time dilation is not an instrument fault. Proper length is measured in the object rest frame; a contracted length is measured in a frame where it moves.

2.4 proper time. proper time means Time between events measured at one location in a frame.

3.1 $\gamma = 1.25$; proper lifetime = 8 microseconds. Lab distance = $0.60 \times 3 \times 10^8 \times 10^{-5} = 1,800$ m. Birth and decay occur at the same particle-frame location.