INTERNATIONAL BACCALAUREATE · IB DIPLOMA · PHYSICS · HL • EXERCISE SHEET

5.1 Relativity and measuring events

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS proper time • inertial frame

Objective

Relativity and measuring events. Original classroom practice for IB HL; not an official IB paper.

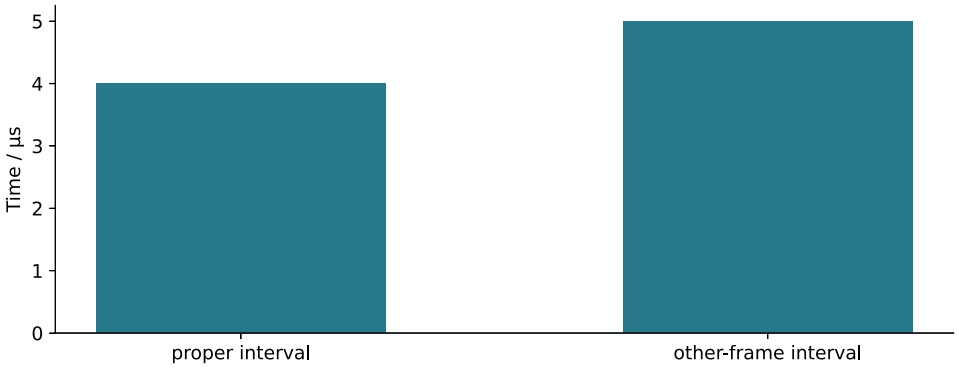
1 Key knowledge and worked examples

■ 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.

■ 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.

In the lab: 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

- 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.

Your turn: A proper interval is 8 microseconds and gamma is 1.25. Find the other-frame interval.

■ 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.

Not true: All inertial observers must measure the same time interval between any two events. Simultaneity and duration are frame-dependent: inertial observers in relative motion generally measure different time intervals between the same two events. Only the proper interval, measured in the rest frame of the events, is shared.

Key:

- In special relativity, inertial observers measure the same vacuum light speed.
- The Lorentz factor is 1 divided by the square root of 1 minus speed squared over light speed squared.
- Watch for: time dilation is not an instrument fault.

■ Write from a dilated interval of 18 microseconds

- A proper interval is 12 microseconds and gamma is 1.5.
- Find the interval in the other frame. Inertial observers need not agree on the duration.

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]