

APOLLO

Galilean and special relativity

HL

Physics

First assessment 2025

10 questions | questions

9. Observer X sees a spacecraft moving in the positive x -direction at a speed of $0.50c$.

Observer Y sees the same spacecraft moving in the negative x -direction at a speed of $0.50c$.

What is the speed of Y in the frame of reference of X?

- A. 0
- B. $0.80c$
- C. c
- D. $1.3c$

— 0 —

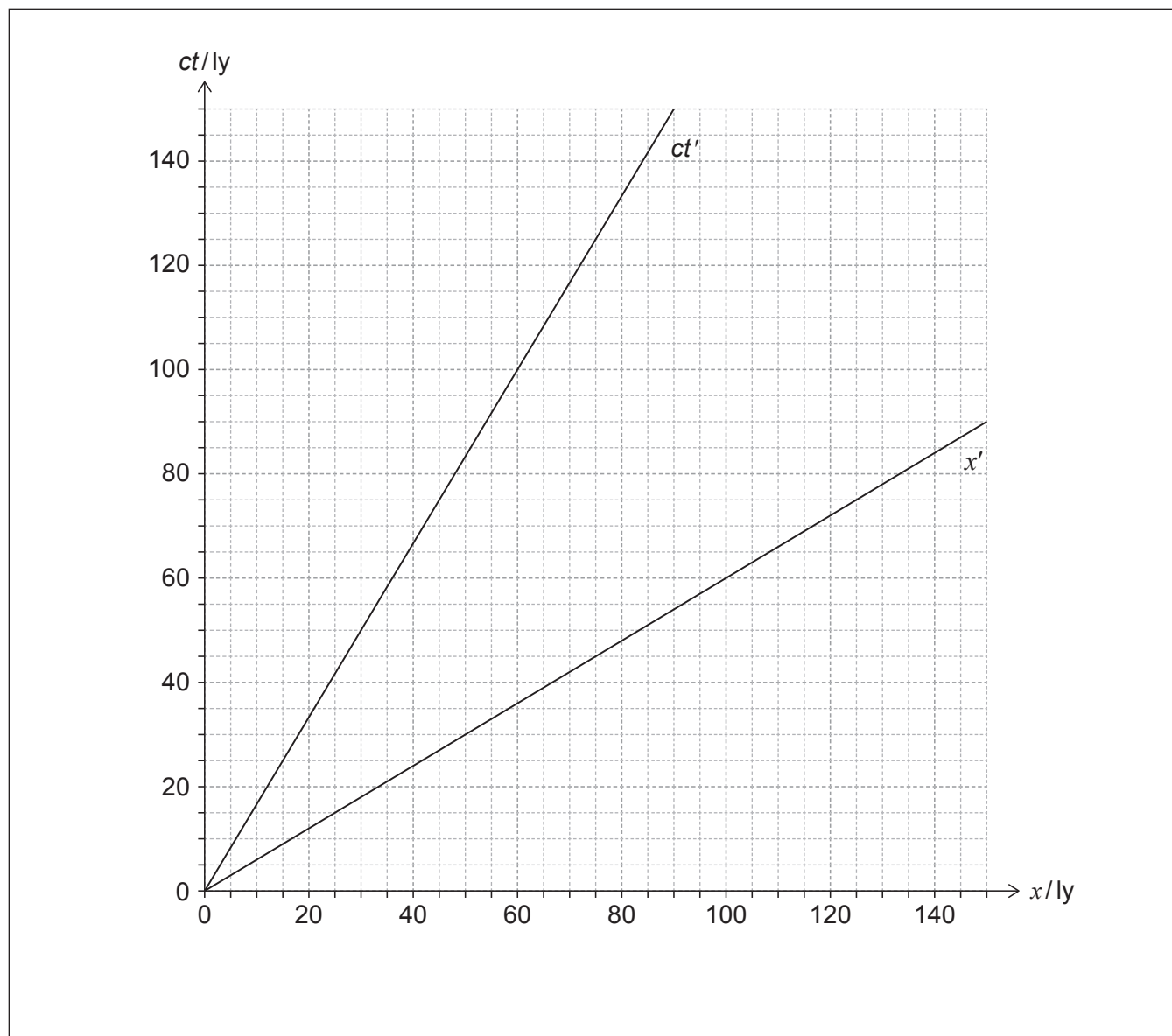
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2225-0101

9. A pendulum has a period of 3.0 s as measured in its inertial frame of reference. An observer is moving with a speed of $0.80c$ with respect to the pendulum's frame.

What is the period of the pendulum measured by the observer?

- A. 8.3 s
- B. 5.0 s
- C. 1.8 s
- D. 1.1 s

6. Spacecraft S leaves Earth with speed $0.60c$ on the way to a planet P. As measured by Earth, P is at a distance of 30 ly from Earth. The diagram shows the spacetime axes of Earth (x, ct) and of S (x', ct').



(This question continues on the following page)



(Question 6 continued)

- (a)
 S arrives at P after 50 years according to Earth. Calculate the time at which S arrives at P according to S clocks.
 [2]

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- (b)
 When S arrives at P, S sends a radio signal back to Earth.

- (i)
 Draw, on the spacetime diagram, the world line of the signal from when it is emitted until it is received on Earth.
 [1]

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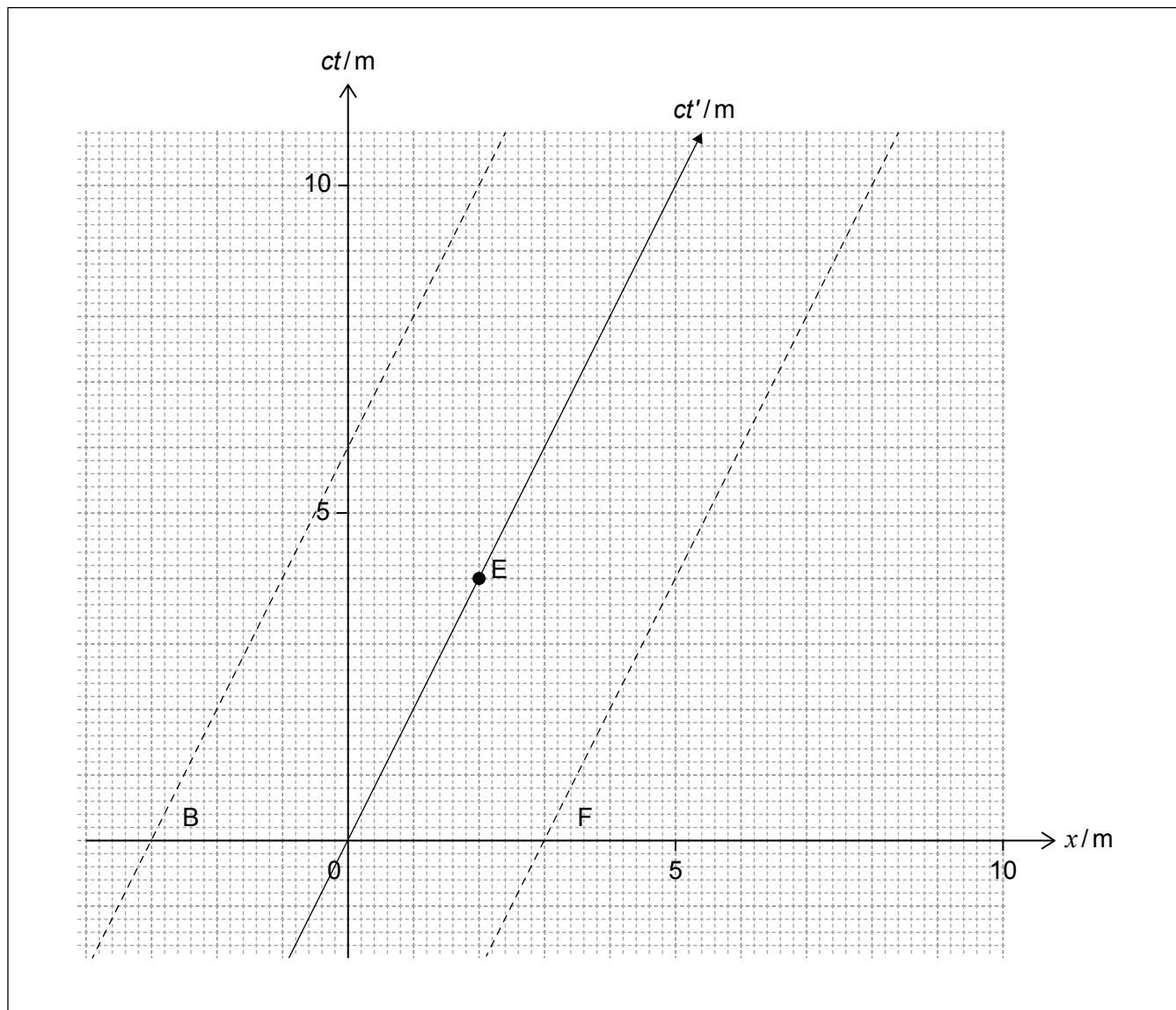
- (ii)
 Determine, using the spacetime diagram or otherwise, the time of travel of the signal according to S.
 [3]

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2. The spacetime diagram shows the x , ct axes for an observer on the ground. The ct' axis for a passenger on a train moving relative to the observer and world lines for the back (B) and front (F) of the moving train are also shown. The observer on the ground and the passenger are opposite each other at the origin of the spacetime diagram.

The train is travelling at $0.5c$.



Event E is the lighting of a match by the passenger in the train, with coordinates $x = 2$ m and $ct = 4$ m. The light from the match reaches two mirrors at the back and front of the train.

- (a) Draw, on the graph, the x' axis for the passenger on the train. [1]
- (b) Draw, on the graph, the path of the light emitted from the match to show the events where the light strikes both mirrors. Label the events T_B and T_F . [1]

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(Question 2 continued)

- (c)
Explain, with reference to T_B and T_F , which person concludes that the light reached both mirrors simultaneously.
- [2]

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- (d)
State the length of the train for the observer on the ground.
- [1]

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4420-0121

8. A muon of proper lifetime t is produced in the high atmosphere and travels towards Earth at a relativistic speed v . What is the distance travelled by the muon in the reference frame of Earth?

A. vt

B. $vt\left(1 - \frac{v^2}{c^2}\right)$

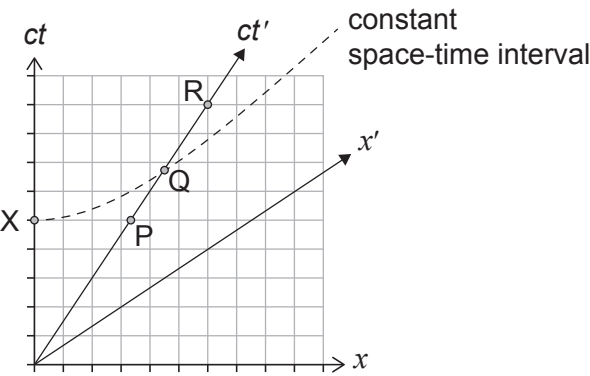
C. $vt\sqrt{1 - \frac{v^2}{c^2}}$

D. $\frac{vt}{\sqrt{1 - \frac{v^2}{c^2}}}$

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9. The space–time diagram shows coordinate axes of inertial reference frames $S(x, ct)$ and $S'(x', ct')$. Event X occurs at $t = 1\text{ s}$ according to the S reference frame. A line of constant space–time interval is drawn through X.



In the S' reference frame, which event is simultaneous with X and which event has the time coordinate $t' = 1\text{ s}$?

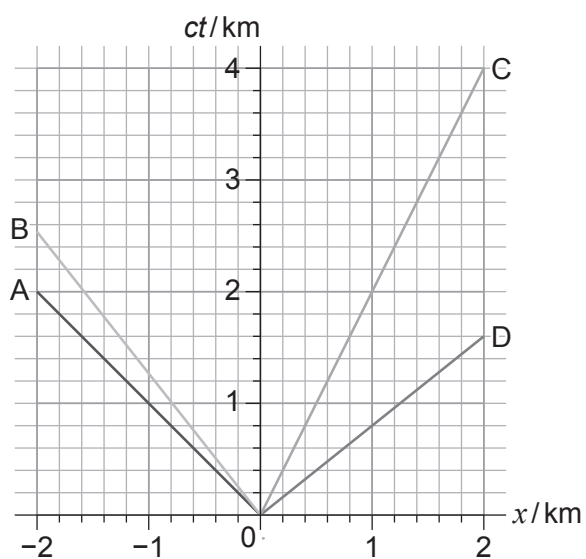
	Simultaneous with X in the S' frame	$t' = 1\text{ s}$ in the S' frame
A.	P	R
B.	Q	R
C.	R	P
D.	R	Q

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0020-0101

8. Rocket R travels away from an observer on Earth at a speed of $0.80c$. A space–time diagram shows four world lines.

What is the correct world line of R in the reference frame of Earth?



9. The fixed distance between Earth and a star measured in Earth's reference frame is d_E . A spaceship travels from Earth to the star at a constant speed of $0.8c$ relative to Earth. The distance between Earth and the star as measured by the spaceship is d_s .

What is $\frac{d_s}{d_E}$?

- A. $\frac{3}{5}$
- B. $\frac{4}{5}$
- C. $\frac{5}{4}$
- D. $\frac{5}{3}$

— v —

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0025-0719

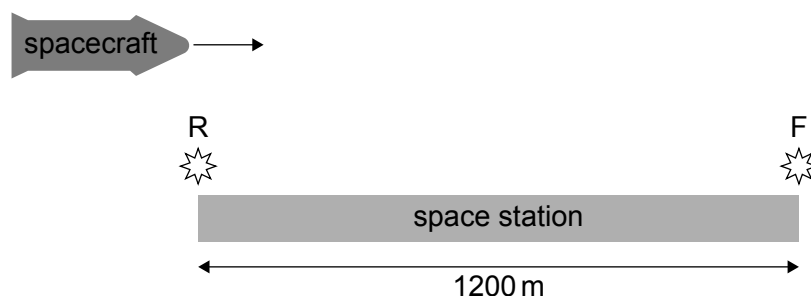
9. A spacecraft, moving with speed v relative to Earth, passes Earth on its way to a planet. As the spacecraft passes Earth, clocks on Earth and in the spacecraft show zero.

The planet is a distance D from Earth, according to an observer on Earth.

What are the readings on the Earth clock and on the spacecraft clock when the spacecraft arrives at the planet?

	Earth clock reading	Spacecraft clock reading
A.	$\frac{D}{v}$	$\frac{D}{v} \sqrt{1 - \frac{v^2}{c^2}}$
B.	$\frac{D}{v}$	$\frac{D}{v \sqrt{1 - \frac{v^2}{c^2}}}$
C.	$\frac{D}{v \sqrt{1 - \frac{v^2}{c^2}}}$	$\frac{D}{v}$
D.	$\frac{D}{v} \sqrt{1 - \frac{v^2}{c^2}}$	$\frac{D}{v}$

2. A spacecraft is flying past a space station at a relative speed of $0.80c$. Beacons, R and F, at each end of the space station emit light pulses at the same time according to observers on the space station. The pulses are emitted 1200 m apart as measured by space station observers.



- (a) Calculate γ for a speed of $0.80c$.

[1]

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- (b) Calculate, for the reference frame of the spacecraft,

- (i) the distance between the light pulses.

[1]

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- (ii) the time between the light pulses.

[2]

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- (c) Determine which light pulse happened first.

[2]

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