

Sample Final Exam — Einstein and Relativity

Multiple choice

1. A passenger train travels east at high speed. William stands at the west end of that train, Emily stands at the east end. In the train's frame, William and Emily cough at the same time. In the earth's frame,
- they cough simultaneously.
 - William coughs first.
 - Emily coughs first.
 - they sneeze instead of cough.

Answer: b — relativity of simultaneity (rear event happens first).

2. Harold travels from the Earth to the star Sirius, eight light years away. In Harold's frame
- the trip takes more time than it does in the Earth's frame.
 - Harold travels to Sirius over a length that is shorter than eight light years.
 - clocks on Earth and on Sirius are synchronized.
 - Sirius travels to Harold over a length that is shorter than eight light years.

Answer: d — length contraction.

3. An earthworm has eight hearts located at different parts of its body. The eight hearts must all beat at the same time in order to produce effective blood circulation. If an earthworm flies past us in a rocket ship traveling at half the speed of light, its front hearts will be out of synch with its rear hearts. Nevertheless, the earthworm remains alive because
- the worm is so short (due to length contraction) that it doesn't need effective blood circulation.
 - the worm is not perfectly rigid.
 - the hearts remain synchronized in the worm's own frame.
 - both the heartbeats and the respiration rate slow down.

Answer: c — the phenomena mentioned in a, b, and d all occur, but do not explain why the earthworm remains alive.

4. When his wall clock reads noon, Caleb leaves his house and travels to the grocery store at a speed of $V = \frac{4}{5}c$. His wrist watch records 60 minutes for the trip. What time does the store's clock read when he arrives? (All three clocks involved keep excellent time.)
- a. 12:36 b. 12:48 c. 1:00 d. 1:15 e. 1:40

Answer: e — time dilation (the moving clock ticks slowly, in this case by a factor of $\frac{3}{5}$).

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5. Ignore the rotation of the earth. Which clock ticks more slowly?

- a. The one on the top of a mountain.
- b. The one at the bottom of that same mountain.
- c. They tick at the same rate.
- d. Cannot be determined from the information given.

Answer: b — gravitational time dilation (lower clock ticks slowly).

Short answer

Veronica races down a 200-foot-long straight track at uniform speed $\frac{4}{5}c$ (so that $\sqrt{1 - (V/c)^2} = \frac{3}{5}$). There are clocks at the start line and at the finish line. The start-line clock reads 0 nans as Veronica passes.

1. How much time does her race require (in earth's frame)? [This is the time that will be displayed on the finish-line clock when Veronica passes it.]
2. How much time does Veronica's wristwatch tick off during her race?
3. In Veronica's frame, the finish line moves toward her. How long is the racetrack in Veronica's frame?
4. In Veronica's frame, when she passes the start line (and the start-line clock reads 0 nans), what does the finish-line clock read?
5. In Veronica's frame, how much time does the finish-line clock tick off during her race?
6. Sum the answers to 4 and 5, and compare with the result of 1.