special relativity - practice problems

1. Two observers move at constant velocity relative to each other. Each observer says the other observer's clock runs slow. Why is that not a contradiction?

2. A research probe passes Earth at 0.60c. Earth is the observer frame, and the probe is moving relative to Earth. What Lorentz factor does Earth use for the probe?

3. A particle beam moves at 2.40 × 10 8 m/s relative to a laboratory detector on Earth. What fraction of c is that, and what Lorentz factor does the laboratory observer use?

4. A clock inside a spacecraft records an 8.0 minute engine burn. Earth observers see the spacecraft moving at 0.80c. According to Earth, how long does the burn last?

5. Earth observers measure a high-speed trip lasting 30 years. The spacecraft moves at 0.95c relative to Earth. How much time passes for an astronaut riding with the spacecraft?

6. A student says, "Time dilation just means the moving clock looks slow because the light from it takes longer to reach us." What is missing from that explanation?

7. Muons created high in the atmosphere have a rest-frame half-life of 2.2 microseconds. Earth observers see the muons moving at 0.98c. What half-life do Earth observers measure?

8. A moving clock ticks once every 5.0 s in its own frame. A lab observer measures 9.0 s between those ticks. How fast is the clock moving relative to the lab, as a fraction of c?

9. A survey ship is 120 m long in its own rest frame. It passes Earth lengthwise at 0.75c. What length does an Earth observer measure for the moving ship?

10. A spacecraft is moving horizontally across your screen. Does special relativity make its height contract?

11. Earth observers measure a passing experimental railcar as 72 m long while it moves at 0.88c relative to Earth. The railcar has 12 windows, but that does not matter here. What is the railcar's rest length according to an observer riding with it?

12. A spacecraft moving at 0.90c relative to Earth flashes a nose light and a tail light. The lights are 40 m apart in the spacecraft frame, and the ship clock says the flashes happen 3.0 ns apart. What time interval does Earth measure between the flashes?

13. A sealed 4.0 g sample sits at rest on a lab bench. The lab observer wants its rest energy. What is the sample's rest energy in joules?

14. If a stationary object has rest energy, why does it not explode or release that energy just by sitting there?

15. A proton has mass 1.67 × 10 -27 kg and moves at 0.80c relative to a detector. What total relativistic energy does the detector observer assign to the proton?

16. A 1200 kg spacecraft moves at 0.20c relative to Earth. Earth observers use the relativistic kinetic energy equation from the page. How much kinetic energy do they assign to the spacecraft?

17. Why should a relativity solution say which observer measures the time or length?

18. A space station observer measures two events separated by 6.0 years and 4.0 light-years in the x direction. There is no y or z separation. What spacetime interval squared does that observer calculate?

19. An electron and positron are nearly at rest before they annihilate. Use electron mass 9.11 × 10 -31 kg. If the annihilation makes two identical photons, what energy does each photon have in joules?

20. A spacecraft moves at 0.92c relative to Earth. An astronaut at rest inside the spacecraft measures a repair taking 3.0 hours, and the spacecraft's rest length is 80 m. What repair time and ship length do Earth observers measure?