

Special Relativity Questions and Problems

Questions

1. Does time dilation mean that time actually passes more slowly in moving reference frame or that it only *seems* to pass more slowly? Explain your answer.
2. If you were traveling away from Earth at speed $0.5c$, would you notice a change in your heartbeat? Would your mass, height, or waistline change? What would observers on Earth using telescopes say about you?
3. Do time dilation and length contraction occur at ordinary speeds? Explain.
4. Can a particle of nonzero rest mass attain the speed of light? Give an example and explain.

Problems

1. A spaceship passes you at a speed of $0.750c$. You measure its length to be 28.2 m. How long would it be when at rest? **42.6 m**
2. A muon (a subatomic particle) travels at a speed of 2.7×10^8 m/s. At this speed, the average lifetime is measured to be 4.76×10^{-6} s. What is the particle's lifetime at rest?
3. From Earth you measure the distance to a star to be 125 light-years (a distance). If you are traveling at a speed of 2.70×10^8 m/s toward the star, what would you measure this distance to be?
4. What is the speed of a *pion* (a sub-atomic particle) if its average lifetime is measured to be 4.10×10^{-8} s? At rest, its average lifetime is 2.60×10^{-8} s.
5. In an Earth reference frame, a star is 82 light-years away. How fast would you have to travel so the distance to the star would be only 25 light-years?
6. At what speed v will the length of a 1.00-m stick look 10.0% shorter (90.0 cm)?
7. A friend speeds by you in her "Ferrari" spacecraft at a speed of $0.660c$. It is measured in your frame to be 4.80 m long and 1.25 m high. (a) What will be its length and height at rest? (b) How many seconds would you say elapsed on your friend's watch when 20.0 s passed on yours? (c) How fast did you appear to be traveling according to your friend? (d) How many seconds would she say elapsed on your watch when she saw 20.0 s pass on hers?
8. An astronaut on a spaceship traveling at $0.75c$ relative to Earth measures his ship to be 25 m long. On the ship, he eats his lunch in 23 min. (a) What length is the spaceship according to observers on Earth? (b) How long does the astronaut's lunch take to eat according to observers on Earth?
9. What is the mass of a proton traveling at $v = 0.965c$?
10. What is the speed of an electron whose mass is 10,000 times its rest mass?

Relativistic Velocity Transformations

1. A person on a rocket traveling at $0.50c$ (with respect to the Earth) observes a meteor come from behind and pass her at a speed she measures as $0.50c$. How fast is the meteor moving with respect to the Earth?
2. Two spaceships leave Earth in opposite directions, each with a speed of $0.50c$ with respect to Earth. (a) What is the velocity of spaceship 1 relative to spaceship 2? (b) What is the velocity of spaceship 2 relative to spaceship 1?
3. A spaceship leaves Earth traveling at $0.71c$. A second spaceship leaves the first at a speed of $0.87c$ with respect to the first. Calculate the speed of the second ship with respect to Earth if it is fired (a) in the same direction the first spaceship is already moving, (b) directly backward toward Earth.
4. An observer on Earth sees an alien vessel approach at a speed of $0.60c$. The *Enterprise* comes to the rescue, overtaking the aliens while moving directly toward Earth at a speed of $0.90c$ relative to Earth. What is the relative speed of one vessel as seen by the other?
5. Rocket A passes Earth at a speed of $0.75c$. At the same time, rocket B passes Earth moving $0.95c$ relative to Earth in the same direction. How fast is B moving relative to A when it passes A.
6. You are traveling in a spaceship at a speed of $0.85c$ away from Earth. You send a laser beam toward the Earth traveling at velocity c relative to you. What do observers on the Earth measure for the speed of the laser beam?