Relativity Test

by Tarang Srivastava

1. At what speed does a clock move if it runs at a rate which is one-half the rate of a clock at rest?

2. At what speed does a meter stick move if its length is observed to shrink to 0.5 m?

3. The average lifetime of a π meson in its own frame of reference is 26.0 ns. (this is its proper lifetime)

- if the π meson moves with speed $0.95c$ with respect to the Earth, what is its lifetime as measured by an observer at rest on Earth?
- What is the average distance it travels before decaying as measured by an observer at rest on Earth?

4. An atomic clock is placed in a jet airplane. The clock measures a time interval of 3600s when the jet moves with speed 500 m/s. How much larges a time interval does an identical clock held by an observer at rest on the ground measure?

5. A rod of length L_0 moves with speed v along the horizontal direction. The rod makes an angle θ_0 with respect to the x' axis.

- Determine the length of the rod as measured by a stationary observer.
- Determine the angle θ the rod makes with the x axis.

6. Relativistic Doppler Shift

- How fast and in what direction must galaxy A be moving if an absorption line found at wavelength 550nm (green) for a stationary galaxy is shifted to 450 nm (blue) ("blue shift")?
- How fast and in what direction is galaxy B moving if it shows the same line shifted to 700nm (red) ("red shift")?

7. A stationary observer on Earth observes spaceships A and B moving in the same direction toward the Earth. Spaceship A has speed 0.5c and spaceship B has speed 0.8c. Determine the velocity of spaceship A as measured by an observer at rest in spaceship B.

8. Two rockets of rest length L_0 are approaching the earth from opposite directions at velocities $\pm c/2$. How long does one appear to the other?

9. A person comes to you claiming that he/she has invented a microchip 1 cm square in size which can run at a clock speed of $300,000$GHz. Would you invest in this person's company so that he/she can manufacture and market his/her new invention? Explain your answer.

10. Two spaceships approach each other. They are each viewed from Earth as having a speed half that of light. What is their speed relative to each other?

11. If you move toward an emitter of yellow light ($\lambda = 580nm$) at half the speed of light, what wavelength would you observe? What would be the answer if the emitter moved toward you?

12. A beam of muons is injected in a storage ring, a device that uses electromagnetic fields to maintain the muons in uniform circular motion. The ring's radius is 60m, and the muons are injected with a velocity such that $\gamma = 15$. How many revolutions of the ring will an "average" muon make before it decays? The proper lifetime of a muon is 2.2×10^{-6}s.