Name: _____ **Date:** _____

Cosmic Speed Traps: A High School Freshman Modern Physics Quest

How does reality change when things get fast and small? Synthesize relativity and quantum mechanics across these 10 challenging problems.

---

1. A muon particle is created in the upper atmosphere and travel toward Earth at 0.99c. From the muon's perspective, the distance to the ground appears shorter than recorded by a stationary observer. This is an example of:

A. Gravitational Lensing
B. Length Contraction
C. The Pauli Exclusion Principle
D. Quantum Entanglement

2. In the context of the wave-particle duality, the _____ experiment proves that even individual electrons create interference patterns, behaving like waves until measured.

A. Michelson-Morley
B. Double-Slit
C. Millikan Oil Drop
D. Cavendish

3. According to General Relativity, a clock placed at the base of a massive skyscraper will tick slightly slower than a clock at the top of the skyscraper.

A. True
B. False

4. If you are designing a highly sensitive scanning probe, which quantum phenomenon allows electrons to pass through a physical vacuum barrier they technically lack the energy to cross?

A. Nuclear Fusion
B. Quantum Tunneling
C. Spontaneous Emission
D. The Compton Effect

5. The concept that 'the observer affects the observed,' specifically regarding the impossibility of perfectly measuring both position and velocity, is known as _____.

A. Einstein's Equivalence Principle
B. Hawking Radiation
C. The Heisenberg Uncertainty Principle
D. The Cosmological Constant

6. $E=mc^2$ implies that even a small amount of mass can be converted into a massive amount of energy because the constant 'c' (the speed of light) is a very large number.

Name: _____ **Date:** _____

A. True
B. False

7. Which of these provides the best evidence for General Relativity's claim that mass warps the fabric of spacetime?

A. The cooling of the Cosmic Microwave Background
B. The observation of Gravitational Waves from colliding black holes
C. The speed of sound in a vacuum
D. The color of distant red dwarfs

8. When light of a high enough frequency hits a silicon plate and ejects electrons to create current, we call this the _____ effect.

A. Doppler
B. Photoelectric
C. Stark
D. Zeeman

9. In the 'Twins Paradox,' one twin stays on Earth while the other travels to a distant star at light-speed and returns. Why is the traveling twin younger?

A. Biological cells divide slower in space regardless of speed
B. The acceleration of the ship creates time dilation
C. Special Relativity shows time elapses slower for the moving frame
D. The vacuum of space preserves mass-energy

10. Quantum mechanics suggests that at the subatomic level, particles have definite, fixed locations at all times, even when we are not looking at them.

A. True
B. False