Relativity PT

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. Relativity equations for time, length, and momentum hold true for
a. everyday low speeds.
b. relativistic speeds.
c. both A and B
d. none of the above

____ 2. The correspondence principle says that
a. any new theory must correctly predict observations.
b. the new theory is correct.
c. the old theory is correct.
d. any new theory must agree with the old correct theory.

____ 3. If Einstein's equations of special relativity are valid, they must
a. reduce to Newton's equations when the speed is small.
b. give correct answers for speeds much less than the speed of light.
c. agree with the correct results of Newton's equations.
d. both A and C
e. A, B, and C

____ 4. A woman standing on the ground sees a rocket ship move past her at 95% the speed of light. Compared to the rocket at rest, the woman sees the rocket's length as
a. longer.
b. the same.
c. shorter.

____ 5. A 10-meter-long spear is thrown at a relativistic speed through a 10-meter-long pipe (both measured when at rest.) When the spear passes through the pipe,
a. the pipe shrinks so the spear extends at both ends.
b. both shrink equally so the pipe barely covers the spear.
c. the spear shrinks so the pipe completely covers it.
d. any of the above, depending on the motion of the observer
e. none of the above

____ 6. When you approach a light source, the wavelength of emitted light appears _____.
a. shorter b. the same c. longer

____ 7. As a blinking light source approaches you at an increasing speed, the frequency of the flashes
a. increases. b. stays the same. c. decreases.

____ 8. Compared to time kept on Earth, there is a physical slowing of time when you travel at _____.
a. everyday low speeds.
b. relativistic speeds.
c. both A and B
d. none of the above

____ 9. Einstein reasoned that _____.
a. all motion is relative

b. a spaceship cannot measure its speed relative to empty space
c. a spaceship can only measure its speed relative to other objects
d. all of the above

____ 10. Suppose an alien invites you to take a trip on her spaceship. If you travel at the speed of light, you would be
a. travelling through neither space nor time
b. travelling through both space and time
c. travelling through time but not through space
d. travelling through space but not through time

True/False
Indicate whether the statement is true or false.

____ 11. In the presence of strong gravitational fields, four-dimensional geometry must be used in place of Euclidean geometry.

____ 12. Einstein's special relativity cannot explain why Mercury precesses an extra 43 arc seconds per century beyond the precession expected due to the effects of the other planets.

____ 13. If a person takes a ride on a fast-moving spaceship, she will return to Earth older than she would be if she had stayed on Earth for the same length of time.

____ 14. Einstein reasoned that space and time are two parts of one whole called space-time.

____ 15. The speed of light can change when measured in different reference frames.

Essay

16. How much rest energy is contained in a 0.01-kg quarter?

17. The sun radiates about 3.6×10^{26} joules of energy each second. How much mass does the sun lose each second?

18. Derive the time dilation equation found in Section 15.6 of the text. Explain each step of the derivation.

Problem

19. What is the energy equivalent of 5.0 kg of mass?

20. What is the mass equivalent of 2.0 MJ?

Relativity PT
Answer Section

MULTIPLE CHOICE

1. ANS: C PTS: 1 DIF: L1 OBJ: 16.3 The Correspondence Principle
   STA: Ph.6.f KEY: relativity | time | momentum BLM: knowledge
2. ANS: D PTS: 1 DIF: L1 OBJ: 16.3 The Correspondence Principle
   STA: Ph.6.f KEY: correspondence | principle BLM: knowledge
3. ANS: E PTS: 1 DIF: L2 OBJ: 16.3 The Correspondence Principle
   STA: Ph.6.f KEY: Einstein | Newton BLM: analysis
4. ANS: C PTS: 1 DIF: L2 OBJ: 15.6 Length Contraction
   KEY: speed | light BLM: comprehension
5. ANS: D PTS: 1 DIF: L2 OBJ: 15.6 Length Contraction
   KEY: relativistic | observer BLM: comprehension
6. ANS: A PTS: 1 DIF: L2 OBJ: 15.5 Space and Time Travel
   KEY: wavelength BLM: comprehension
7. ANS: A PTS: 1 DIF: L2 OBJ: 15.5 Space and Time Travel
   KEY: light | speed | increase BLM: comprehension
8. ANS: C PTS: 1 DIF: L2 OBJ: 15.4 Time Dilation
   KEY: time | slow BLM: comprehension
9. ANS: D PTS: 1 DIF: L1
   OBJ: 15.2 The First Postulate of Special Relativity KEY: Einstein | relative
   BLM: knowledge
10. ANS: D PTS: 1 DIF: L2 OBJ: 15.1 Space-Time
    KEY: space-time | time dilation BLM: application

TRUE/FALSE

11. ANS: T PTS: 1 DIF: L1
    OBJ: 16.5 Gravity, Space, and a New Geometry KEY: gravity | geometry | relativity
    BLM: knowledge
12. ANS: F PTS: 1 DIF: L2 OBJ: 16.6 Tests of General Relativity
    KEY: general relativity | precession BLM: knowledge
13. ANS: F PTS: 1 DIF: L2 OBJ: 15.5 Space and Time Travel
    KEY: time | distance | speed BLM: comprehension
14. ANS: T PTS: 1 DIF: L1 OBJ: 15.1 Space-Time
    KEY: Einstein | space | time BLM: knowledge
15. ANS: F PTS: 1 DIF: L2
    OBJ: 15.3 The Second Postulate of Special Relativity KEY: relativity
    BLM: knowledge

ESSAY

16. ANS:
    $E_0 = mc^2 = (0.01 \text{ kg})(3 \times 10^8 \text{ m/s})^2 = 9.0 \times 10^{14} \text{ J}$

PTS: 1 DIF: L2 OBJ: 16.2 Equivalence of Mass and Energy
KEY: rest | energy | mass BLM: application

17. ANS:

$$m = \frac{E_0}{c^2} = \frac{3.6 \times 10^{26}\ \text{J}}{\left(3 \times 10^8 \text{m/s}\right)^2} = 4.0 \times 10^9 \text{ kg lost each second!}$$

PTS: 1 DIF: L2 OBJ: 16.2 Equivalence of Mass and Energy
KEY: mass | energy | loss BLM: application

18. ANS:
The product $c \cdot t$ represents the distance the light flash moves in going to the top mirror. The product $c \cdot t_o$ represents the distance a person moving with the mirror sees the light flash move, and the product $v \cdot t$ is the distance the ship has moved in time t. Applying the Pythagorean Theorem to this triangle, we have the equation shown in the box titled "The Time Dilation Equation."

PTS: 1 DIF: L2 OBJ: 15.4 Time Dilation
KEY: derivation | dilation BLM: analysis

PROBLEM

19. ANS:
4.5×10^{17} J

PTS: 1 DIF: L2 OBJ: 16.2 Equivalence of Mass and Energy
KEY: energy | mass | equation BLM: application

20. ANS:
2.2×10^{-11} kg

PTS: 1 DIF: L2 OBJ: 16.2 Equivalence of Mass and Energy
KEY: mass BLM: application