Name: _____ Date: _____

___ **1.** Two electrons move in opposite directions at 0.70c as measured in the laboratory. The speed of one electron as measured from the other is:
A) 0.35c **B)** 0.70c **C)** 0.94c **D)** 1.00c **E)** 1.40c

___ **2.** Visible light, with a frequency of 6.0×10^{14} Hz, is reflected from a spaceship moving directly away at a speed of 0.90c. The frequency of the reflected waves observed at the source is:
A) 3.2×10^{13} Hz
B) 1.4×10^{14} Hz
C) 6.0×10^{14} Hz
D) 2.6×10^{15} Hz
E) 1.1×10^{16} Hz

___ **3.** Two events occur 100 m apart with an intervening time interval of 0.60 μs. The speed of a reference frame in which they occur at the same coordinate is:
A) 0 **B)** 0.25c **C)** 0.56c **D)** 1.1c **E)** 1.8c

___ **4.** An electron ($m = 9.11 \times 10^{-31}$ kg) has a momentum of 4.0×10^{-22} kg · m/s. Its kinetic energy is:
A) 6.3×10^{-14} J
B) 8.2×10^{-14} J
C) 1.2×10^{-13} J
D) 1.5×10^{-13} J
E) 2.7×10^{-13} J

___ **5.** The velocity of an electron is changed from $c/2$ in the $-x$ direction to $c/2$ in the $+x$ direction. As a result, its kinetic energy changes by:
A) mc^2 **B)** $0.5mc^2$ **C)** $\sqrt{2}mc^2$ **D)** $2mc^2$ **E)** zero

___ **6.** An electron ($m = 9.11 \times 10^{-31}$ kg) has a speed of 0.95c. Its kinetic energy is:
A) 8.2×10^{-14} J
B) 1.8×10^{-13} J
C) 2.0×10^{-13} J
D) 2.2×10^{-13} J
E) 2.6×10^{-13} J

___ **7.** The proper time between two events is measured by clocks at rest in a reference frame in which the two events:
A) occur at the same time
B) occur at the same coordinates
C) are separated by the distance a light signal can travel during the time interval
D) occur in Boston
E) satisfy none of the above

___ **8.** A clock is moving along the x axis at $0.6c$. It reads zero as it passes the origin ($x = 0$). When it passes the $x = 180$ m mark on the x axis the clock reads:
A) 0.60 μs **B)** 0.80 μs **C)** 1.00 μs **D)** 1.25 μs **E)** 1.67 μs

___ **9.** Two events occur 100 m apart with an intervening time interval of 0.37 μs. The speed of a clock that measures the proper time between the events is:
A) 0 **B)** $0.45c$ **C)** $0.56c$ **D)** $0.90c$ **E)** $1.8c$

___ **10.** Two events occur on the x axis separated in time by Δt and in space by Δx. A reference frame, traveling at less than the speed of light, in which the two events occur at the same coordinate:
A) exists no matter what the values of Δx and Δt
B) exists only if $\Delta x/\Delta t < c$
C) exists only if $\Delta x/\Delta t > c$
D) exists only if $\Delta x/\Delta t = c$
E) does not exist under any condition

___ **11.** A source at rest emits light of wavelength 500 nm. When it is moving at $0.90c$ away from an observer, the observer detects light of wavelength:
A) 26 nm **B)** 115 nm **C)** 500 nm **D)** 2200 nm **E)** 9500 nm

___ **12.** Two independent events occur 100 m apart with an intervening time interval of 0.42 μs. The proper time in μs between the events is:
A) 0 **B)** 0.16 **C)** 0.26 **D)** 0.42 **E)** 0.69

___ **13.** A train traveling very fast ($v = 0.6c$) has an engineer (E) at the front, a guard (G) at the rear, and an observer (S′) exactly half way between them. Both E and G are equipped with yellow signaling lamps. The train passes a station, closely observed by the station master (S). Both E and G use their lamps to send signals. According to both S and S′ these signals arrive simultaneously at the instant S′ is passing S. According to S′:

A) E and G sent their signals simultaneously from different distances
B) G sent his signal before E and from farther away
C) G sent his signal before E but was the same distance away
D) E sent his signal before G and from farther away
E) none of the above

___ **14.** A basic postulate of Einstein's theory of relativity is:

A) moving clocks run more slowly than when they are at rest
B) moving rods are shorter than when they are at rest
C) light has both wave and particle properties
D) the laws of physics must be the same for observers moving with uniform velocity relative to each other
E) everything is relative

___ **15.** The mass of a particle is m. In order for its total energy to be twice its rest energy, its momentum must be:

A) $mc/2$ **B)** $mc/\sqrt{2}$ **C)** mc **D)** $\sqrt{3}mc$ **E)** $2mc$

___ **16.** A meson moving through a laboratory of length x at a speed v decays after a lifetime T as measured by an observer at rest in the laboratory. If the meson were at rest in the laboratory its lifetime would be:

A) $T(1-v/c)$
B) $T(1-v/c)^{-1}$
C) $T(1-v^2/c^2)^{-1/2}$
D) $T(1-v^2/c^2)^{1/2}$
E) $(T-vx/c^2)(1-v^2/c^2)^{-1/2}$

___ **17.** If the kinetic energy of a particle is equal to its rest energy then its speed must be:

A) $0.25c$ **B)** $0.50c$ **C)** $0.87c$ **D)** c **E)** unknown unless its mass is given

___ **18.** According to the special theory of relativity:

A) all forms of energy have mass-like properties
B) moving particles lose mass
C) momentum is not conserved in high speed collisions
D) a rod moving rapidly sideways is shorter along its length
E) a rod moving rapidly sideways is longer along its length

___ **19.** Two flashes of light occur simultaneously at $t = 0$ in reference frame S, one at $x = 0$ and the other at $x = 600$ m. They are observed in reference frame S′, which is moving at $0.95c$ in the positive x direction. The origins of the two frames coincide at $t = 0$ and the clocks of S′ are zeroed when the origins coincide. In S′ the coordinate where the leading edges of the two light flashes meet and the time when they meet are:

A) 300 m, 1.0 μs
B) 15 m, 0.050 μs
C) 585 m, 1.95 μs
D) 49 m, 0.16 μs
E) 1900 m, 0.16 μs

___ **20.** A source at rest emits light of wavelength 500 nm. When it is moving at $0.90c$ toward an observer, the observer detects light of wavelength:

A) 26 nm **B)** 115 nm **C)** 500 nm **D)** 2200 nm **E)** 9500 nm

Answer Key

1. C
   Origin: Chapter 38- Special Relativity, 38
2. A
   Origin: Chapter 38- Special Relativity, 47
3. C
   Origin: Chapter 38- Special Relativity, 15
4. A
   Origin: Chapter 38- Special Relativity, 64
5. E
   Origin: Chapter 38- Special Relativity, 51
6. B
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7. B
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8. B
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9. D
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10. B
    Origin: Chapter 38- Special Relativity, 12
11. D
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12. C
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13. E
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14. D
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15. D
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16. D
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17. C
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18. A
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19. D
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20. B
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