ZCT 104/3E Modern Physics
Semester II, Sessi 2005/06
Test I (20 Dec 2006)

Data

Speed of light in free space, $c = 3.00 \times 10^{8}$ ms^{-1}
Elementary charge, $e = 1.60 \times 10^{-19}$ C
The Planck constant, $h = 6.63 \times 10^{-34}$ J s
Unified atomic mass constant, $u = 1.66 \times 10^{-27}$ kg
Rest mass of electron, $m_e = 9.11 \times 10^{-31}$ kg
Rest mass of proton, $m_p = 1.67 \times 10^{-27}$ kg

1. Say you put two clocks (clock A and clock B) in front of you and set them to 00.00am at standard local time. Then you ask your friend to send one of them (clock B) to ET's home some 300 million meters away. At one fine day, you decide to compare the reading of both clocks. The reading of clock A (which lies in front of you) reads 12.00 pm. Let say you can view clock B (now located at 300 million meters away) through a telescope. Which statement is correct about the reading of clock B as seen by you when peeking though the telescope?

   A. The reading of clock B seen though the telescope is the same as the reading of clock A.
   B. The reading of clock B seen though the telescope is different from the reading of clock A.
   C. No conclusive statement can be made for the relation between the reading of clock B and clock A
   D. (None of **A**, **B**, **C**)

   ANS:B, My own questions

2. Your friend is running at a speed of v towards you. He throws out a ball towards you, and the speed of the ball is u with respect to him. What is the speed of the ball measured by you?

   A. $u + v$
   B. $u - v$
   C. $v - u$
   D. (None of **A**, **B**, **C**)

   ANS:A, My own questions

3. Reconsider question 2 above. Your friend is running at a speed of v towards you. He shines a beam of light towards you. The speed of the light is c with respect to him. What is the speed of the light as measured by you?

   A. $c + v$
   B. $c - v$
   C. c
   D. (None of **A**, **B**, **C**)

   ANS:C, My own questions

4. While standing beside a railroad track, we are startled by a boxcar traveling past us at half the speed of light. A passenger standing at the rear of the boxcar fires a laser pulse toward the front of the boxcar. The pulse is absorbed at the front of the box car. While standing beside the track we measure the speed of the pulse through the open side door. The measured value of the time of flight of the pulse is _____ than that measured by the rider.
   A. greater than
   B. equal to
   C. less than
   D. (None of **A**, **B**, **C**)

   ANS:A, My own questions

5. Given two events, A and B, of which space and time coordinate are respectively designated by (x_A, t_A) and (x_B, t_B). Which of the following statements are (is) correct?

I. Both events must be causally related
II. Both events must not be causally related
III. Both events may be causally related
IV. Both events may be causally unrelated

A. I, II
B. III, IV
C. I, II, III, IV
D. (None of **A**, **B**, **C**)

ANS: B

6. Given a species of fly has an average lifespan of τ. Let say you put 1000 of them in box A and send them to a destination at some remote destination in deep space using a rocket that travel at speed v. The destination is located at a distance of L from Earth. Considering only special relativistic effect and assuming that None of the flies die of any cause other than aging, which of the following statements is (are) correct? (Lorentz factor is defined as $\gamma = [1-(v/c)^2]^{-1/2}$).

I. Most of the flies would have not survived if the location of the destination $L/v > \tau$
II. Most of the flies would survive if $(L/v) < \tau$
III. Most of the flies would survive if $(1/\gamma)\ (L/v) < \tau$
IV. Most of the flies would have not survived if $(1/\gamma)\ (L/v) > \tau$

A. I , IV
B. II, III, IV
C. III, IV
D. (None of **A**, **B**, **C**)

ANS: B

7. Say Azmi is travelling in a mini bus moving with speed v (with respect to Earth) and Baba is sitting in Pelita Nasi Kandar restaurant. Using his own wristwatch, Azmi finds that his heart beats at a rate of N_A times per min. When Baba measures the heartbeat rate of Azmi in the Pelita frame, he found that Azmi's heart is beating at a rate of N_B times a min. What is the relation between the two reading, N_A and N_B?

A. $N_A > N_B$
B. $N_A < N_B$
C. $N_A = N_B$
D. (None of **A**, **B**, **C**)

ANS: A

8. Consider a football, kicked lightly by David Beckham, is moving in a straight line with constant speed. Say in frame O, the momentum of the football is P. In a frame O′ moving with a relative constant speed with respect to O, the momentum of football is P'. Which of the following statements are (is) true regarding P and P'?

I. Classically, P and P' have a same numerical value.
II. Relativistically, P and P' have a same numerical value.
III. Classically, P and P' have a different numerical value.
IV. Relativistically, P and P' have a different numerical value.

A. I , II
B. III, IV
C. I, II, III, IV
D. (None of **A**, **B**, **C**)

ANS: B

9. In a given reference frame, O, the velocity of an object (which rest mass is m_0) is v_1. The velocity of the same object in another frame, O', which moves with a relative velocity u with respect to O, is v_2. What is the momentum of the object in these frames? (In the following, $\gamma(v) = 1/\sqrt{1-(v/c)^2}$).
   A. The momentum of the object in frame O is $m_0\gamma(v_1)v_1$ whereas in frame O' the momentum is $m_0\gamma(v_2)v_2$
   B. The momentum of the object in frame O' is $m_0\gamma(v_1)v_1$ whereas in frame O the momentum is $m_0\gamma(v_2)v_2$
   C. The momentum of the object in both frames is $m_0\gamma(u)u$.
   D. (None of **A**, **B**, **C**)

ANS: A

10. Which of the following statement is true regarding the linear momentum of an object?
   A. In general the relativistic momentum is larger in magnitude than the corresponding classical momentum.
   B. In general the relativistic momentum is smaller in magnitude than the corresponding classical momentum.
   C. In general classical momentum and relativistic momentum has the same magnitude.
   D. (None of **A**, **B**, **C**)

ANS: A

11. Which of the following statements is (are) true regarding the kinetic energy of an object?

   I. The kinetic energy of an object can increase indefinitely
   II. In special relativity, the kinetic energy of an object = the increase in the total relativistic energy of the object due to its motion
   III. The relativistic kinetic energy reduces to the non-relativistic form of $mv^2/2$ when $v \ll c$
   IV. The largest possible kinetic energy of an object is $mc^2/2$.

   A. I , IV
   B. II, III, IV
   C. I , II, III
   D. (None of **A**, **B**, **C**)

ANS: C

12. Which statements in the following is (are) true?
   I. Observer in different inertial frames can disagree about the speed of light in free space
   II. Observer in different inertial frames can disagree about the location of an event
   III. Observer in different inertial frames can disagree about the time separating two events
   IV. Proper time is the amount of time separating two events that occurs at the same location

   A. II, III, IV
   B. II, III
   C. I, II, III, IV
   D. (None of **A**, **B**, **C**)

ANS: A

13. Which statements in the following is (are) true?
   I. The rest energy as predicted by special relativity has no analogue in classical mechanics
   II. Work done by a force on a system is converted into mechanical energy of the system
   III. Force exerted on a system causes the momentum of the system to change at a rate proportional to the force
   IV. The change of momentum of a system causes a force to exert on the system

   A. I , II
   B. I, II, III
   C. I , II, III, IV

D. (None of **A**, **B**, **C**)

ANS: B

14. The relativistic kinetic energy of an object, in general, is

A. greater than that defined by the classical mechanics
B. less than that defined by the classical mechanics
C. always equal to that defined by classical mechanics
D. (None of **A**, **B**, **C**)
ANS: A

15. A clock moving with a finite speed *v* is observed to run slow. If the speed of light were tripled, you would observe the clock to be

A. Even slower.
B. Still slow but not as much
C. As slow as it was
D. To start to actually run fast.

ANS: B (Walker test bank, Chap 29, Q26)

16. Which of the following results shows the validity of the relativistic effect of time dilation?

A. The conservation of linear momentum in electron-electron collision
B. Bending of light near the Sun
C. The decay of muons
D. Null result in the Michelson-Morley experiment on Ether detection
ANS: C (Walker test bank, Chap 29, Q27)

17. A spaceship travelling at constant speed passes by Earth and later passes by Mars. In which frame of reference is the amount of time separating these two events the proper time?

A. The Earth frame of reference
B. The spaceship frame of reference
C. Any inertial frame of reference
D. The Mars frame of reference
ANS: B (Walker test bank, Chap 29, Q13)

18. Boat 1 goes directly across a stream a distance L and back taking a time t_1. Boat 2 goes down stream a distance L and back taking a time t_2. If both boats had the same speed relative to the water, which of the following statements is true?

A. $t_2 > t_1$.
B. $t_2 < t_1$.
C. $t_2 = t_1$.
D. (None of **A**, **B**, **C**)

ANS: A (Serway test bank, Chap 39, Q6)
Solution: $t_1 = L/v_{boat,stream}$; $t_2 = L / [(v_{boat,stream} - (v_{stream}^2/v_{boat,stream})]$ $\therefore$ $t_1 < t_2$

19. The speed of light is

A. 3×10^8 m/s
B. 3×10^6 m/s
C. 3×10^9 m/s
D. 3×10^7 m/s

ANS: A

20. The quantity which does not change in numerical value from that observed in system S when observed in system S' moving away from system S at speed v is

A. $(\Delta x)^2 - (c\Delta t)^2$
B. $m_0 v$
C. $(\gamma\text{-}1)\, m_0 c^2$
D. (None of **A**, **B**, **C**)

ANS: A (Serway test bank, Chap 39, Q33)