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Physics 3710 – Exam I

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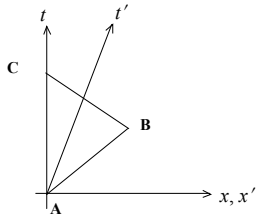
Questions 1-2 refer to: The log-log "history of the universe" graph.

1. Primordial nucleosynthesis occurs approximately between logarithmic times 2 and 2.5. The number of seconds for this period is about
(a) 0.5
(b) 2
(c) 2.5
(d) 200

2. During the radiation dominated period, radiation energy (in eV) varies with time, *t* (in seconds), as $E = 1.8 \times 10^5 / \sqrt{t}$. On the graph, the radiation energy versus time curve is a straight line with slope equal to
(a) –0.5
(b) +0.5
(c) $+\log_{10}(1.8 \times 10^5)$
(d) $+1.8 \times 10^5$

Questions 3-5 refer to: **Newtonian** observer O records a sound pulse traveling with constant speed from event **A** to event **B**. The sound pulse is reflected at **B** and travels to event **C** at the *same speed* according to O. A second **Newtonian** observer O′ traveling at constant speed relative to O records the same events. A spacetime diagram of these events according to O is shown to the right.



3. Which one of the following is true?
(a) $x'_B > x_B, x'_C < x_C$
(b) $x'_B < x_B, x'_C < x_C$
(c) $x'_B > x_B, x'_C > x_C$
(d) $x'_B = x_B, x'_C = x_C$

4. Which one of the following is true?
(a) $t'_B > t_B, t'_C < t_C$
(b) $t'_B < t_B, t'_C < t_C$
(c) $t'_B > t_B, t'_C > t_C$
(d) $t'_B = t_B, t'_C = t_C$

5. Which one of the following is true? According to O′ the speed of the pulse between **A** and **B** is
(a) equal to the speed between **B** and **C**
(b) greater than the speed between **B** and **C**
(c) less than the speed between **B** and **C**
(d) either greater or less than the speed between **B** and **C** depending on the relative speed of O

Questions 6-8 refer to: As seen from Earth, a particle created at an altitude of 25 km (event A) decays just as it reaches Earth's surface (event B), 30 km after creation (in units in which *c* =1).

6. What is the speed of the particle as seen from Earth?
(a) 1/2
(b) 3/5
(c) 5/6
(d) 1

7. What is the distance (in km) between A and B according to the particle?
(a) 0 km
(b) 13.8 km
(c) 16.6 km
(d) 30 km

8. What is the lifetime (in km) of the particle in its own rest frame?
(a) 16.6 km
(b) 25 km
(c) 30 km
(d) 54.3 km

9. Without correction, the clocks aboard a GPS satellite in each orbit would differ from clocks on Earth due to their relative motion. Which one of the following is true? In each orbit the satellite clocks would be
(a) slower by a few nanoseconds relative to the Earth clocks
(b) faster by a few nanoseconds relative to the Earth clocks
(c) slower by a few microsecond relative to the Earth clocks
(d) faster by a few microseconds relative to the Earth clocks

Questions 10-13 refer to: Suppose (x,T) refers to the s-t coordinates of events according to an observer O at rest relative to Earth. A rocket leaves Earth at (0, 0) (event A) and travels at constant speed to a distant star arriving at (4, 5) (event B). Immediately thereafter a light signal is sent from the star back to Earth, and is received at Earth at event C.

10. The coordinates of C are
(a) (0, 9)
(b) (4, 9)
(c) (5, 9)
(d) (0, 4)

11. The proper time between A and C is
(a) 3
(b) 4
(c) 5
(d) 9

12. The sum of the proper times for A to B plus B to C is
(a) 3
(b) 4
(c) 5
(d) 9

13. The distance from Earth to the star *at the time of event A* according to the rocket is
(a) 9
(b) 5
(c) 4
(d) 2.4

Questions 14-15 refer to: O′ travels relative to O with a constant (dimensionless) *x*-velocity +0.8.

14. O records the velocity of a rocket to be +0.5 in the *x-direction*. The *x′-component* of the velocity of the rocket according to O′ is
(a) –0.5
(b) –0.3
(c) +0.5
(d) +0.8

15. O records the velocity of a second rocket to be +0.5 in the *y-direction*. The *x′-component* of the velocity of the rocket according to O′ is
(a) 0
(b) –0.3
(c) –0.5
(d) –0.8

Questions 16-19 refer to: Two identical masses, m = 1 (in some units), collide head-on and form a composite body of mass M. According to observer O, initially each mass has a $\tilde{\gamma}$ = 5/3.

16. According to O, the total *momentum* (in mass units) of the system before and after the collision is
(a) 0
(b) 2
(c) 8/3
(d) 10/3

17. According to O, the total *energy* (in mass units) of the system before and after the collision is
(a) 0
(b) 2
(c) 8/3
(d) 10/3

18. The mass of the *composite* body is
(a) 0
(b) 2
(c) 8/3
(d) 10/3

19. As a result of the collision, according to O, the kinetic energy of the system
(a) is conserved with value equal to 4/3
(b) is conserved with value equal to 8/3
(c) decreases by 4/3
(c) increases by 8/3

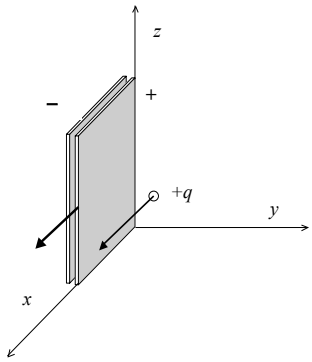
Questions 20-21 refer to: The mass of the neutron is 1.009 u and that of the proton is 1.007 u. 1 u = 931.5 MeV.

20. Suppose a neutron decays into a proton and other low mass particles. The total energy, in u, of the low mass particles is
(a) 2.016 u
(b) 1.009 u
(c) 1.007 u
(d) 0.002 u

21. The mass of a calcium-40 nucleus (*Z* protons = 20, *N* neutrons = 20) is 40 u. The binding energy, in eV, per nucleon is on the order of
(a) 0.001 MeV
(b) 0.1 MeV
(c) 10 MeV
(d) 1000 MeV

22. A typical fission process releases about 0.8 MeV per nucleon. A typical fusion process releases, per nucleon, about
(a) 0.02 MeV
(b) 0.1 MeV
(c) 0.8 MeV
(d) 6 MeV

Questions 23-25 refer to: The figure to the right shows (portions of) two uniform, infinite planar sheets of charge. As seen by observer O at rest with respect to the negative sheet the positive sheet travels along the +*x*-axis with (dimensionless) speed *u*. According to O, the charge densities (charge per unit area) on the positive and negative sheets are σ_+ and σ_-, with $\sigma_+ = -\sigma_-$. At one instant, a positive test charge has a (dimensionless) velocity +*u* in the *x*-direction.



23. In the next instant, O will observe the test charge
(a) continue undeflected with velocity +*u* in the *x*-direction
(b) deflect in the –*y*-direction because of a magnetic force
(c) deflect in the +*z*-direction because of a magnetic force
(d) deflect in the +*y*-direction because of an electric force

24. In the next instant, observer O', initially at rest with respect to the test charge, will observe the test charge
(a) continue with velocity +*u* in the *y*-direction
(b) deflect in the +*y*-direction because of a magnetic force
(c) deflect in the –*z*-direction because of a magnetic force
(d) deflect in the –*y*-direction because of an electric force

25. If the positive sheet is brought to rest in O its charge density
(a) will still be σ_+
(b) will decrease to $\sqrt{1-u^2}\,\sigma_+$
(c) will increase to $\sigma_+ \big/ \sqrt{1-u^2}$
(d) will change sign and be σ_-