Marks Scored:

KATHMANDU UNIVERSITY
End Semester Examination
March, 2017

Level : B. Sc.
Year : III
Course : PHYS 312
Semester : II
Exam Roll No. :
Time: 30 mins.
F. M. : 20
Registration No.:
Date : MAR 2 4 2017

SECTION "A"
[20 Q. × 1 =20 marks]

Choose and tick (√) the most appropriate answer.

1. A 1000-kg automobile moving with a speed of 24 m/s collides with a 500-kg car initially at rest. If the two stick together, what is the velocity (in m/s) of the two cars after the collision relative to an automobile moving in the same direction at 15 m/s?
[a] 14 [b] 16 [c] 24 [d] 1.0

2. Which one is a variant under Galilean transformations?
[a] velocity . [b] acceleration.
[c] the law of conservation of momentum. [d] Newton's II Law.

3. At what speed should a clock be moved so that it may appear to lose 1 minute in each hour?
[a] 5.4×10^{7} cm/s [b] 5.4×10^{8} m/s [c] 5.4×10^{7} m/s [d] 1.8×10^{8} m/s

4. A 30-year-old woman takes a trip on a rocket, leaving her 20-year-old brother behind. She travels at a speed of 0.8 c, and is gone 20 years, according to the younger brother. When she returns, how many years older/younger is she than her brother?
[a] 2 years younger [b] 2 years older [c] 3 years older [d] 10 years older

5. Captain Jirk reports to headquarters that he left the planet Senesca 1.88×10^{4} seconds earlier. Headquarters sends back the message: "Was that spaceship proper time?" It will be spaceship proper time if it was
[a] measured by one clock fixed at one spot on Senesca.
[b] measured by one clock fixed at one spot on the spaceship.
[c] measured by a clock on Senesca at departure and by a clock on the spaceship when reporting.
[d] calculated by dividing the distance from Senesca according to Senesca by the speed of the spaceship.

6. Which of the following statements is NOT CORRECT?
[a] Velocity of light is the maximum range of velocity attainable in nature.
[b] A moving clock runs more slowly than a stationary one.
[c] The length of moving rod is contracted in a direction perpendicular to the direction of motion.
[d] The velocity of light is an absolute constant independent of the motion of the reference system.

7. Special theory of relativity treats problems involving

[a] inertial frame of reference. [b] non-inertial frame of reference.
[c] non-accelerated frame of reference. [d] accelerated frame of reference.

8. An astronaut traveling with a speed $v = 0.9\ c$ holds a meterstick in his hand. If he measures its length, he will obtain a value of

[a] 2.3 m [b] 0.19 m [c] 1 m [d] 0.43 m

9. Two β-particles A and B travel in opposite directions each with a velocity 0.9 c. What is their relative velocity as observed by A?

[a] 0.99 c [b] 0.99 [c] c [d] 0.9 c

10. The velocity at which the mass of a particle becomes 8 times its rest mass is

[a] 0.992 c [b] 0.882 c [c] 8 c [d] 0.8 c

11. Energy is released during a nuclear reaction due to a conversion between mass and energy. Mass is not conserved. The initial and final amounts are different. If a total of 1 gram of mass is "missing", how much energy has been released?

[a] 9.0×10^{11} J [b] 9.0×10^{17} J [c] 9.0×10^{13} J [d] 9.0×10^{16} J

12. An electron ($m = 9.1 \times 10^{-31}$ kg) has a speed of 0.90 c. What is the difference between its relativistic momentum and its non-relativistic momentum (in kg m/s)?

[a] 4.3×10^{-22} [b] 3.3×10^{-22} [c] 5.4×10^{-22} [d] 6.5×10^{-22}

13. The relativistic Lagrangian function is

[a] $L = \left\{1 - \sqrt{\left(1 - \frac{v^2}{c^2}\right)}\right\} - V$ [b] $L = m_0 c^2 \left\{1 - \sqrt{\left(1 - \frac{v^2}{c^2}\right)}\right\} + V$

[c] $L = m_0 c^2 \left\{1 - \sqrt{\left(1 - \frac{v^2}{c^2}\right)}\right\} - V$ [d] $L = \left\{m_0 c^2 - \sqrt{\left(1 - \frac{v^2}{c^2}\right)}\right\} - V$

14. The trajectory of a particle on a Minkowski diagram is called a

[a] world line [b] light cone [c] space-like vector [d] time-like vector

15. The expression for the relativistic Hamiltonian is

[a] $H = [c\sqrt{\{p_x^2 + p_y^2 + p_z^2 + m_0^2 c^2\}} - 1 + V]$ [b]

$H = [c\sqrt{\{p_x^2 + p_y^2 + p_z^2 + m_0^2 c^2\}} - m_0 c^2 + V]$

[c] $H = [c\sqrt{\{p_x^2 + p_y^2 + p_z^2 + m_0^2 c^2\}} + V]$ [d]

$H = [c\sqrt{\{p_x^2 + p_y^2 + p_z^2 + m_0^2 c^2\}} - m_0 c^2 + V$

16. Referred to space-time as "the world." Hence, events are world points and a collection of events giving the history of a particle is a world line.

[a] Newton [b] Lagrange [c] Minkowski [d] Hamiltonian

17. The interval between two events in Minkowski space is
[a] depend on Newtonian frame of reference.
[b] depend on Non -Newtonian frame of reference.
[c] depend on both Newtonian and Non –Newtonian frame of references.
[d] independent of the frame of reference.

18. A hypothetical particle that travels faster than light is called
[a] photon.
[b] neutrino.
[c] tachyon.
[d] electron.

19. Which of the following gives Hamilton's canonical equations in covariant form?
[a] $\dot{x}^{\mu} = \frac{\partial H}{\partial x^{\mu}}$ and $\dot{\mathrm{p}}^{\mu} = -\frac{\partial H}{\partial p^{\mu}}$
[b] $\dot{x}^{\mu} = \frac{\partial H}{\partial p^{\mu}}$ and $\dot{\mathrm{p}}^{\mu} = \frac{\partial H}{\partial x^{\mu}}$
[c] $x^{\mu} = \frac{\partial H}{\partial p^{\mu}}$ and $\mathrm{p}^{\mu} = -\frac{\partial H}{\partial x^{\mu}}$
[d] $\dot{x}^{\mu} = \frac{\partial H}{\partial p^{\mu}}$ and $\dot{\mathrm{p}}^{\mu} = -\frac{\partial H}{\partial x^{\mu}}$

20. Modified Hamilton's Principle is
[a] $\delta \int_{t_1}^{t_2} \left[\sum_k p_k \dot{q}_k - H(q,p,t) \right] dt = 0$
[b] $\delta \int_{t_1}^{t_2} \left[\sum_k \dot{p}_k q_k - H(q,p,t) \right] dt = 0$
[c] $\delta \int_{t_1}^{t_2} \left[\sum_k p_k \dot{q}_k - L(q,p,t) \right] dt = 0$
[d] $\delta \int_{t_1}^{t_2} \left[\sum_k p_k \dot{q}_k \right] dt - H(q,p,t) = 0$

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SECTION "B"
[5Q × 4 = 20 marks]

Attempt *ALL* questions of the followings:

1. Explain with suitable examples the meaning of inertial and non-inertial frames of reference. Your laboratory fixed on earth is inertial or non-inertial?

2. Calculate the fringe-shift in Michelson-Morley experiment. Given that l = 11 m, v = 30 km/sec and $\lambda = 6\times10^{-5}$ cm.

   OR

   An electron is moving with a speed of 0.85 c in a direction opposite to that of a moving photon. Calculate the relative velocity of the electron and photon.

3. A π-meson of rest mass m_π decays into a μ-meson of mass m_μ and a neutrino of mass m_υ. Show that the total energy of the μ-meson is $\frac{1}{2m_\pi}[m_\pi^2 + m_\mu^2 - m_\upsilon^2]\,c^2$.

4. Describe the relativistic classification of particles in Minkowski space.

   OR

   What is a four vector? Find the components of velocity four-vector and show that its magnitude is invariant.

5. Use Hamilton's principle to derive relativistic Lagrange's equations.

SECTION "C"
[5Q × 7 = 35 marks]

Attempt *ALL* questions of the followings:

6. What are Galilean Transformations? Derive Galilean transformation equations and show that the law of conservation of linear momentum can be obtained from the law of conservation of energy and the principle of Galilean invariance.

7. State and explain the fundamental postulates of special theory of relativity and deduce the Lorentz transformations. Prove that when v<<c, Lorentz transformations reduce to Galilean one.

   OR

   What do you mean by the phenomenon of aberration? Use Lorentz transformation equations to obtain the formulae for aberration. Compare it with the classical formula.

8. Deduce the relation between mass and energy $E = mc^2$ and discuss the equivalence of mass and energy. How much electric energy could theoretically be obtained by annihilation of 1 gm of matter?

OR

Derive Einstein relation $E^2 = p^2c^2 + m_0^2c^4$, where the symbols have their usual significance. Also, show that the rest mass of a particle of momentum p and kinetic energy T is $m_0 = \frac{p^2c^2 - T^2}{2T\,c^2}$.

9. Explain the space like and time like intervals in Minkowski space with necessary diagrams.

10. Give relativistic formulation of Hamiltonian and hence derive canonical equations of motion in covariant form.