

Time : 3 Hours

Marks :100

N.B.:

1. All questions are compulsory.
2. Figures to the right indicate full marks.
3. Draw neat diagrams wherever necessary.
4. Symbols have usual meaning unless otherwise stated.
5. Use of non-programmable calculator is allowed.

- Q1.** Attempt any **two**
- (i) Derive Lorentz transformation equations for space and time. **10**
  - (ii) Write a short note on **10**
    - a) Inertial and non-inertial frames of reference.
    - b) Simultaneity in relativity.
  - (iii) Explain what is Stellar aberration? Why ether drag hypothesis was rejected? **10**
  - (iv) Explain the invariance of physical law. Obtain the Galilean transformation for velocity and acceleration and hence shows that force remain invariant under Galilean transformation. **10**
- Q2** Attempt any **two**
- (i) What is twin paradox? Explain the resolution of twin paradox. Draw space-time diagram of twin paradox. **10**
  - (ii) Derive relativistic equation for aberration of light. **10**
  - (iii) State and explain Transverse Doppler effect. **10**  
A source of light emitting light of wavelength 6000 AU is moving along the circumference of a circle with a constant speed of  $0.6c$  relative to an observer fixed at the centre of the circle. Find the wavelength of light as observed by the observer.
  - (iv) Derive Lorentz transformation equations for velocity. Using it show that the velocity of light remains the same in all inertial frames of reference. **10**
- Q3** Attempt any **two**
- (i) Derive an expression for Einstein's relativistic mass considering elastic collision between two identical spherical bodies. **10**
  - (ii) Deduce the Lorentz transformations of force. **10**
  - (iii) Derive Lorentz transformation equations of momentum components and energy. **10**
  - (iv) In relativistic mechanics derive an expression for longitudinal and transverse acceleration. **10**

- Q4** Attempt any **two**
- (i) Show that electric fields and magnetic fields cannot exist independently as separate quantities but are interdependent. **10**
  - (ii) A long straight wire is carrying a current lies along X-axis of the frame S. Find the components of electric intensity and magnetic induction produced by the wire relative to the frame S and S'. Hence show that if a stationary charge is lying in the field, near the wire then net electromagnetic force acting on it is zero from the frame S and S'. **10**
  - (iii) Write short notes on: **10**
    - a) Motion of perihelion of the mercury
    - b) General theory of relativity
  - (iv) Show that the electric field of a uniformly moving point electric charge in an inertial frame of reference loses its spherical symmetry. **10**
- Q5.** Attempt any **four**
- (i) Transform the displacement vector  $10\hat{i} + 4\hat{j}$  cm in a system S to S'. Velocity of S' frame relative to frame S is  $0.7c\hat{i}$ . **05**
  - (ii) Calculate the velocity of a meter scale if its length appears to be contracted to 0.2 m. **05**
  - (iii) A source of light of wavelength 5000 A.U. is receding from an observer with a speed of  $0.4c$ . Find the wavelength of light as observed by the stationary observer. **05**
  - (iv) Write a short note on Minkowshki's space-time diagram. **05**
  - (v) With what velocity should a particle move so that the increase in its mass may be 25 % of its rest mass? **05**
  - (vi) The momentum of an electron observed is  $3m_0c$ , where  $m_0$  is rest mass of an electron and  $c$  is the velocity of light. Find the velocity of an electron and its relativistic kinetic energy. **05**
  - (vii) Show that the quantity  $E^2 - c^2B^2$  is invariant under Lorentz transformations. **05**
  - (viii) Derive an expression for the modified frequency of a spectral line due to gravitational red-shift. **05**

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