



**Q.1. Answer the following short questions: (15x2=30)**

- I. State the principle of causality.
- II. Distinguish between time-like, light-like and space-like intervals.
- III. Show that proper time is a scalar quantity.
- IV. Describe Ricci scalar in terms of curvature tensor.
- V. Write down the Maxwell's equations in four-vector interacted with electromagnetic interaction  $A^\mu$ .
- VI. Explain the terms (a) Light Cone (b) Atlas
- VII. Show that the expression  $\chi = X^\mu \partial_\mu$  remains invariant under coordinate transformation.
- VIII. What does  $k < 1$  correspond if  $k > 1$  corresponds physically to a red shift of recession?
- IX. What are the covariant and contravariant components of a vector (tensor)?
- X. What is the rest mass energy of a proton?
- XI. Define geodesics and write its equation on manifold.
- XII. Prove that the partial differentiation of tensors is not tensorial.
- XIII. What is Cosmic Microwave Background (CMB) in cosmology?
- XIV. Deduce the Minkowski line element  $ds^2 = dt^2 - dx^2 - dy^2 - dz^2$  for infinitesimal separated events.
- XV. Describe the concept of ether and explain its demise with the help of Michelson-Morley experiment.

**Answer the following questions. (3x10=30)**

**Question 2:**

Discuss Doppler's effect for light in special relativity and derive its equation.

**Question 3:**

In S frame of reference, two events occur at the origin and a distance X along the x-axis simultaneously at  $t = 0$ . The time interval between the events in  $S'$  is T. Show that the spatial distance between the events in  $S'$  is  $(X^2 + T^2)^{1/2}$  and determine the relative velocity 'v' of the frames in terms of X and T.

**Question 4:**

Show that the Christoffel symbols  $\Gamma_{\mu\rho}^\lambda$  does not follow the coordinate transformation law of a (1, 2) tensor.