St. Philomena's College (Autonomous), Mysore
Question Bank
Programme: M. Sc. Physics
II Semester
Course Title: THEORY OF RELATIVITY-HC
Course Type: Hard Core
Q.P Code: 58101

5 Marks Questions

1. Discuss light cone.
2. Define proper time. Using intervals, show that proper time is slower than the time in rest frame.
3. Define proper length and discuss length contraction using Lorentz transformation equations.
4. Discuss time dilation using Lorentz transformation equations.

6 Marks Questions

1. Discuss the concept of four vectors, and write the components in index notations.
2. Discuss the metric of flat spacetime.
3. Define four-velocity and show that four-velocity is time-like four-vector.

8 Marks Questions

1. Discuss time-like and space-like intervals.
2. Derive Lorentz transformation equations.
3. Derive velocity transformation equations, using Lorentz transformation equations and discuss the limiting cases.
4. Establish the covariant form of Maxwell's electromagnetic field equations by four vectors. Does it represent the covariant formulation of electrodynamics.
5. Discuss the Lorentz invariance of Maxwell's field equations.
6. Derive an expression for quadrupole-moment tensor of the cosmic sources of gravitational waves.
7. Write a note on explosive sources.
8. In detail explain the experimental detection of gravitational waves.
9. Explain in detail the experimental detection of gravitational waves using Laser Interferometric Space Antenna (LISA).

9 Marks Questions

1. Discuss the analog of Newton's second law in special relativistic dynamics and show that four-force and for-velocity are orthogonal.
2. Discuss Energy-Momentum in special relativistic dynamics.

3. Discuss variational principle for the motion of a free particle between two timelike separated points.

4. Obtain the relativistic kinetic energy of a particle.

5. Obtain the expression for Newtonian gravitational potential and discuss inconsistencies of Newtonian gravitation with STR.

6. Discuss Eotvos experiment to test the equality of gravitational and inertial mass.

7. Discuss weak and strong equivalence principles.

8. Discuss the concept of geodesics and derive geodesic equation.

9. Explain the logical steps leading to Einstein's field equations.

10. Discuss Schwarzschild's solution of Einstein's vacuum field equations.

11. Explain the concept of parallel transport in GTR.

12. Discuss curvature tensor and its properties.

13. Write short notes on perihelion advance of planet mercury.

14. Discuss gravitational red shift.

15. Explain gravitational bending of light.

16. Discuss gravitational waves.

17. What is four-vector potential? Show that the Maxwell's field equation can be written in one single equation, given by $\Box^2 A_\mu = \mu_0 J_\mu$, where A_μ is the four vector potential and J_μ is the current four vector. Discuss the covariance of Maxwell's field equations.

18. Express Maxwell's field equations in tensor form and thereby define electromagnetic field tensor. How does this information lead to the covariance of the theory.

19. Derive the expression for the Lorentz force on a charged particle in an electromagnetic field with the help of Lorentz transformation method.

20. Obtain the solution for the wave function assuming that the sources (Tik) are confined to a bounded compact 3-volume using linearized approximation .

21. Obtain the four vector potential of electrodynamics and derive the electro-magnetic field tensor from it. Express the Maxwell's equations in four dimensional formalism and thus prove their Lorentz invariance.

22. Use the transformation properties of the field strength tensor to find the Lorentz transformation for the electric and magnetic fields.

10 Marks Questions

1. Define interval in spacetime and show that interval is invariant in inertial systems.

2. Define four-current and four-vector potentials. How electric and magnetic fields are combined to form the various components of electromagnetic fields tensor? Hence derive the transformation of E and B field.

3. Write the Maxwell's equations in terms of scalar and vector potentials. Show that these equations are invariant under gauge transformations. Discuss the significance of the transformation.

4. Derive an expression for the energy flux of a plane gravitational waves.
5. Explain in detail the experimental detection of gravitational waves using bar detectors.
6. Considering the binary star system obtain an expression for period P of the coalescing binaries.
7. Explain in detail the experimental detection of gravitational waves using Laser interferometers.