

MODEL QUESTION PAPER
B.Sc(Hons) Physics Major
MG4DSEPHY205 THEORY OF RELATIVITY

Duration: 2 Hours

Max. marks : 70

Part A

(Answer any TEN questions. THREE marks each)

1. Can two events be simultaneous for all inertial observers?
2. In units where speed of light is dimensionless with value $c = 1$, what is the physical dimension of energy?
3. When is an invariant interval light-like?
4. If u^μ be components of four-velocity vector evaluate $u^\mu u_\mu$.
5. Show that Minkowski metric tensor is the same in all inertial frames.
6. How does a $(2, 2)$ tensor transform under Lorentz transformation?
7. State the principle of equivalence.
8. State the expression for Christoffel symbol in terms of the basis vectors.
9. Find the covariant derivative of metric tensor $D_\rho g_{\mu\nu}$.
10. Express Riemann tensor components $R^\mu_{\nu\rho\sigma}$ in terms of components of Christoffel symbol.
11. Express Einstein tensor in terms of Ricci tensor and metric tensor.
12. What is a tidal force on geodesics?

Part B

(Answer any 8 questions. FIVE marks each)

13. Lifetime of a neutron in its rest frame is 890 seconds. Find its lifetime in a frame in which neutron is moving at $0.6c$ where c is the speed of light.
14. Frame R' is moving with respect to R at velocity 2.4×10^8 meters second⁻¹. The velocity of a particle is $\mathbf{u} = 2 \hat{\mathbf{x}} + 3 \hat{\mathbf{y}}$ in frame R . Find the velocity \mathbf{u}' in frame R' .
15. Draw the spacetime diagram for a particle in uniform motion.
16. Show that four-acceleration $a^\mu = \frac{du^\mu}{d\tau}$ obeys $a^\mu u_\mu = 0$ always.
17. If $T^{\mu\nu}$ and v^μ are components of a second rank Lorentz tensor and a Lorentz four-vector respectively, show that $w^\mu = T^{\mu\nu} v_\nu$ are components of a Lorentz four-vector.

18. Express the spherical polar basis vectors in terms of Cartesian basis vectors. Obtain the metric tensor components in polar coordinates in polar bases.

19. Distance between two points on the surface of a unit sphere, in polar coordinates (θ, ϕ) , is given to be

$$ds^2 = d\theta^2 + \sin^2 \theta d\phi^2$$

Find the components of Christoffel symbol.

20. Show that covariant derivative $D_\mu V^\nu$ of a vector transforms as a $(1, 1)$ tensor.

21. Find the Riemann tensor components for a space with distance given by

$$ds^2 = dr^2 + r^2 d\theta^2$$

in plane polar coordinates (r, θ) .

22. State Einstein equations and explain the terms.